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#(17-24)

Volume 21, Number 1, January 15, 1967

# NUCLEAR SCIENCE ABSTRACTS

*A semimonthly publication of the USAEC Division of Technical Information, Edward J. Brunenkant, Director. Published by the USAEC Division of Technical Information Extension, Robert L. Shannon, Extension Manager.*

*Nuclear Science Abstracts* provides the only comprehensive coverage, abstracting and indexing of the international literature on nuclear science and technology. *NSA* covers scientific and technical reports of the U. S. Atomic Energy Commission and its contractors, of other U. S. Government agencies and other governments, universities, industrial and research organizations. It also covers patents, books, and journal literature on a world-wide basis. A list of the journals scanned appears in Issues 1 and 13 of each volume. Nearly 400,000 abstracts have appeared in *NSA* through Volume 20. The subject matter covered in *NSA* is described in Issue 1 of each volume and in TID-4552, *Subject Scope of Nuclear Science Abstracts*. The latter is available free from the U. S. Atomic Energy Commission, Division of Technical Information Extension, P. O. Box 62, Oak Ridge, Tennessee 37830.

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# ACKNOWLEDGMENTS

Agreements between the United States Atomic Energy Commission and the following organizations with regard to providing continuing services and specific literature coverage for *Nuclear Science Abstracts* are gratefully acknowledged:

American Institute of Physics; Atomic Energy of Canada Limited; Atomic Energy Research Establishment, United Kingdom; Aktiebolaget Atomenergi, Sweden; European Atomic Energy Community (EURATOM); Gmelin Institute; International Atomic Energy Agency; Japan Atomic Energy Bureau—Japan Atomic Energy Research Institute; Netherlands Patent Office; Reactor Centrum Nederland.

# CORRECTIONS

NSA Vol. 21, No. 1, Abst. No. 1021, line 4 should read: Univ., Canberra). Nucl. Phys., A90: No. 1, 41-55

NSA Vol. 21, No. 1, Abst. No. 1030, line 4 should read: Contract AT(30-1)-937. Nucl. Phys., A90: No. 1, 101-

NSA Vol. 21, No. 1, Abst. No. 1031, line 5 should read: Phys., A90: No. 1, 83-100 (1967).

NSA Vol. 21, No. 1, Abst. No. 1032, line 5 should read: A90: No. 1, 152-8(1967).

NSA Vol. 21, No. 1, Abst. No. 1034, line 5 should read: Nucl. Phys., A90: No. 1, 113-21(1967).

NSA Vol. 21, No. 1, Abst. No. 1035, line 4 should read: Ind.). Nucl. Phys., A90: No. 1, 1-12(1967).

NSA Vol. 21, No. 1, Abst. No. 1050, line 3 should read: R. W.; Fou, C. M. Nucl. Phys., A90: No. 1, 232-40

NSA Vol. 21, No. 1, Abst. No. 1051, line 4 should read: G. C.; Gale, N. H.; Van Heerden, I. J. Nucl. Phys., A90:

NSA Vol. 21, No. 1, Abst. No. 1083, line 5 should read: Nucl. Phys., A90: No. 1, 65-82(1967).

NSA Vol. 21, No. 1, Abst. No. 1084, line 6 should read: A90: No. 1, 186-98(1967).

NSA Vol. 21, No. 1, Abst. No. 1085, line 5 should read: Nucl. Phys., A90: No. 1, 177-85(1967).

NSA Vol. 21, No. 1, Abst. No. 1086, line 4 should read: Univ.). Nucl. Phys., A90: No. 1, 145-51(1967).

NSA Vol. 21, No. 1, Abst. No. 1087, line 4 should read: Dubna, USSR). Nucl. Phys., A90: No. 1, 23-32(1967).

NSA Vol. 21, No. 1, Abst. No. 1088, line 3 should read: dena). Contract AT(04-3)-63. Nucl. Phys., A90: No. 1,

NSA Vol. 21, No. 1, Abst. No. 1127, line 3 should read: (Univ. of Lancaster, Eng.). Nucl. Phys., A90: No. 1,

NSA Vol. 21, No. 1, Abst. No. 1128, line 4 should read: Nucl. Phys., A90: No. 1, 159-76(1967).

NSA Vol. 21, No. 1, Abst. No. 1129, line 3 should read: Nucl. Phys., A90: No. 1, 209-31(1967).

NSA Vol. 21, No. 1, Abst. No. 1130, line 5 should read: Univ., N. J.). Nucl. Phys., A90: No. 1, 199-208(1967).

NSA Vol. 21, No. 1, Abst. No. 1132, line 3 should read: ton). Nucl. Phys., A90: No. 1, 140-4(1967).

NSA Vol. 21, No. 1, Abst. No. 1133, line 3 should read: Rosati, Sergio. Nucl. Phys., A90: No. 1, 13-22(1967).

# CORRECTIONS

NSA Vol. 20, No. 13, Abst. No. 22586, line 2 should read: ATION ON THE ENZYMATIC ACTIVITY OF MITOCHON-. Line 17 should read: aminoethylisothiouronium bromide, serotonin, vitamin $K_1$,. Line 22 should read: the mitochondrial membrane after x irradiation. Decreased levels of

NSA Vol. 20, No. 19, Abst. No. 35869, line 3 should read: Fargo, Jarvis J. Interspace (Int. Pipe Ceram. Corp.) Tech. J., 1: 13-16(1964).

NSA Vol. 20, No. 24, Abst. No. 46113, line 1 should read: SOME ISOTOPIC DEVICES FOR THE USES IN

NSA Vol. 20, No. 24, Abst. No. 46114, line 1 should read: SOME ISOTOPIC DEVICES FOR THE USES IN

NSA Vol. 20, No. 24, Abst. No. 46629, line 10 should read: $^{137}Cs$ had been absorbed. AMP was used as it exhibits

NSA Vol. 21, No. 2, Abst. No. 1372, line 7 should read: $MoO_2$ single crystals. Both electrode leads of the cell are con-

NSA Vol. 21, No. 3, Abst. No. 3656, line 5 should read: (Univ., Strasbourg). Nucl. Phys., A91: 133-44(1967). (In

NSA Vol. 21, No. 3, Abst. No. 4195, line 3 should read: Basel); Brown, Louis. Nucl. Phys., A90: 593-6(1967).

NSA Vol. 21, No. 3, Abst. No. 4196, line 4 should read: Phys., A90: 650-6(1967).

NSA Vol. 21, No. 3, Abst. No. 4197, line 4 should read: Coimbra, Portugal). Nucl. Phys., A90: 597-600(1967).

NSA Vol. 21, No. 3, Abst. No. 4210, line 3 should read: Athens); Duggan, J. L.; Miller, P. D. Nucl. Phys., A91: 97-

NSA Vol. 21, No. 3, Abst. No. 4211, line 3 should read: Nucl. Phys., A91: 209-21 (1967). (ORO-2098-51).

NSA Vol. 21, No. 3, Abst. No. 4212, line 4 should read: A91: 222-4(1967).

NSA Vol. 21, No. 3, Abst. No. 4215, line 2 should read: CLEI. Boeker, E. (Oxford Univ.). Nucl. Phys., A91: 27-

NSA Vol. 21, No. 3, Abst. No. 4216, line 3 should read: (California Inst. of Tech., Pasadena). Nucl. Phys., A90:

NSA Vol. 21, No. 3, Abst. No. 4217, line 3 should read: Univ., Columbus). Nucl. Phys., A90: 601-11(1967).

NSA Vol. 21, No. 3, Abst. No. 4221, line 3 should read: Phys., A91: 164-76(1967).

NSA Vol. 21, No. 3, Abst. No. 4222, line 3 should read: Univ., Zurich); Benenson, Walter. Nucl. Phys., A91: 177-98

NSA Vol. 21, No. 3, Abst. No. 4246, line 4 should read: A91: 44-8(1967).

NSA Vol. 21, No. 3, Abst. No. 4247, line 4 should read: Nucl. Phys., A91: 225-37 (1967).

NSA Vol. 21, No. 3, Abst. No. 4248, line 2 should read: stroem, I. (Univ. of Oslo). Nucl. Phys., A91: 199-208(1967).

NSA Vol. 21, No. 3, Abst. No. 4254, line 3 should read: Onderzoek, Amsterdam). Nucl. Phys., A90: 558-72(1967).

NSA Vol. 21, No. 3, Abst. No. 4255, line 3 should read: ersity Park). Nucl. Phys., A90: 508-22(1967).

NSA Vol. 21, No. 3, Abst. No. 4256, line 4 should read: Nucl. Phys., A90: 657-64 (1967).

NSA Vol. 21, No. 3, Abst. No. 4261, line 4 should read: Tibell, G. (Uppsala Univ.). Nucl. Phys., A90: 673-95(1967).

NSA Vol. 21, No. 3, Abst. No. 4282, line 3 should read: (Vanderbilt Univ., Nashville). Nucl. Phys., A90: 529-44

NSA Vol. 21, No. 3, Abst. No. 4283, line 4 should read: M.; Velinsky, L. J. Nucl. Phys., A90: 573-92(1967).

NSA Vol. 21, No. 3, Abst. No. 4285, line 4 should read: Research, Bombay). Nucl. Phys., A90: 696-704(1967).

NSA Vol. 21, No. 3, Abst. No. 4287, line 4 should read: Molnar, F. Nucl. Phys., A91: 157-63(1967).

NSA Vol. 21, No. 3, Abst. No. 4289, line 4 should read: Nucl. Phys., A91: 49-63 (1967). (In German).

NSA Vol. 21, No. 3, Abst. No. 4296, line 4 should read: A91: 112-22(1967).

NSA Vol. 21, No. 3, Abst. No. 4299, line 3 should read: Energy Commission, Yavne, Israel). Nucl. Phys., A91: 238-40

NSA Vol. 21, No. 3, Abst. No. 4300, line 5 should read: Inst. of Science, Rehovoth, Israel). Nucl. Phys., A91: 85-96

NSA Vol. 21, No. 3, Abst. No. 4336, line 3 should read: Nucl. Phys., A91: 1-26 (1967).

NSA Vol. 21, No. 3, Abst. No. 4337, line 3 should read: H. J. (Univ., Frankfurt am Main). Nucl. Phys., A91: 145-56(1967).

NSA Vol. 21, No. 3, Abst. No. 4342, line 4 should read: Diego, La Jolla). Nucl. Phys., A91: 64-74(1967).

NSA Vol. 21, No. 3, Abst. No. 4343, line 3 should read: G. R. (Oak Ridge National Lab., Tenn.). Nucl. Phys., A91:

NSA Vol. 21, No. 3, Abst. No. 4344, line 3 should read: of Copenhagen). Nucl. Phys., A91: 123-32(1967).

NSA Vol. 21, No. 3, Abst. No. 4347, line 3 should read: (Kansas State Univ., Manhattan). Nucl. Phys., A90: 523-8

NSA Vol. 21, No. 3, Abst. No. 4348, line 4 should read: H. A. (Univ., Heidelberg). Nucl. Phys., A90: 481-507(1967).

NSA Vol. 21, No. 3, Abst. No. 4351, line 3 should read: Nucl. Phys., A90: 625-34 (1967).

NSA Vol. 21, No. 3, Abst. No. 4352, line 3 should read: Komarov, V. V. Nucl. Phys., A90: 635-49(1967).

NSA Vol. 21, No. 3, Abst. No. 4354, line 4 should read: Eindhoven, Netherlands). Nucl. Phys., A90: 612-24(1967).

NSA Vol. 21, No. 3, Abst. No. 4356, line 3 should read: Nucl. Phys., A90: 665-72 (1967). (IITRI-578-P25-18).

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NSA Vol. 21, No. 4, Abst. No. 5487, line 3 should read: Nucl. Phys., A91: 369-81 (1967). (COO-7-398).

NSA Vol. 21, No. 4, Abst. No. 5488, line 3 should read: Nucl. Phys., A91: 382-98 (1967). (COO-7-399).

NSA Vol. 21, No. 4, Abst. No. 5495, line 4 should read: Ger.). Nucl. Phys., A91: 262-72(1967).

NSA Vol. 21, No. 4, Abst. No. 5496, line 4 should read: Phys., A91: 273-91(1967). (LA-DC-8023).

NSA Vol. 21, No. 4, Abst. No. 5511, line 4 should read: Phys. A91: 453-9(1967). (UCRL-14996).

NSA Vol. 21, No. 4, Abst. No. 5512, line 4 should read: Phys., A91: 472-80(1967).

NSA Vol. 21, No. 4, Abst. No. 5513, line 4 should read: Phys., A91: 492-304(1967).

NSA Vol. 21, No. 4, Abst. No. 5514, line 3 should read: Institut fuer Kernphysik, Heidelberg). Nucl. Phys., A91:

NSA Vol. 21, No. 4, Abst. No. 5515, line 2 should read: (Yale Univ., New Haven); Monaro, Sergio. Nucl. Phys., A91:

NSA Vol. 21, No. 4, Abst. No. 5521, line 4 should read: J. P.; Grenacs, L. Nucl. Phys., A91: 439-52(1967).

NSA Vol. 21, No. 4, Abst. No. 5536, line 4 should read: Shestopalova, S. A.; Voinova, N. A. Nucl. Phys., A91: 465-91

NSA Vol. 21, No. 4, Abst. No. 5537, line 4 should read: Lindstroem, H. (Uppsala Univ.). Nucl. Phys., A91: 329-

NSA Vol. 21, No. 4, Abst. No. 5580, line 3 should read: clear Physics Lab., Oxford). Nucl. Phys., A91: 305-18

NSA Vol. 21, No. 4, Abst. No. 5581, line 3 should read: Brighton, Eng.). Nucl. Phys., A91: 460-4(1967).

NSA Vol. 21, No. 4, Abst. No. 5584, line 4 should read: 937, Nucl. Phys., A91: 433-8 (1967). (Puc-937-214).

NSA Vol. 21, No. 4, Abst. No. 5585, line 4 should read: Contract AT(30-1)-937. Nucl. Phys., A91: 399-432(1967).

NSA Vol. 21, No. 4, Abst. No. 5587, line 3 should read: Phys., A91: 241-61(1967).

NSA Vol. 21, No. 8, Abst. No. 12423, line 8 should read: of 1.02±0.01 at 254 mμ was found. Measurements

NSA Vol. 21, No. 10, Abst. No. 17454, line 3 should read: (Static and Dynamic Neutron Flux: An investigation of the

NSA Vol. 21, No. 15, Abst. 25815, line 1 should read: (BNWL-CC-484) RELEASE OF NOBLE GASES FROM

NSA Vol. 21, No. 15, Abst. No. 26154, line 1 should read: (SLAC-PUB-299) DISPLAY CONTROL OF A CRT-

NSA Vol. 21, No. 15, Abst. No. 26793, line 1 should read: (IITRI-578P29-11) RESEARCH ON ZIRCALOY

NSA Vol. 21, No. 15, Abst. No. 27114, line 1 should read: (TID-23705) REPORT OF AD HOC PANEL ON

NSA Vol. 21, No. 15, Abst. No. 27146, line 1 should read: (SU-IPR-100) LANDAU WAVES. Simonen, Thomas C.

NSA Vol. 21, No. 15, Abst. No. 27574, line 1 should read: (NYO-GEN-72-132) PEGRUM NUCLEAR PHYSICS LAB-

# CORRECTIONS

NSA Vol. 20, No. 1, Subject Indexing: NEUTRONS, FAST — scattering by helium-4 at 10 to 700 MeV polarization from, (E), 20: 1134 (ORNL-P-1604) should read: NEUTRONS, Fast — scattering by helium-4 at 10 to 700 keV ...

NSA Vol. 20, No. 8, Abst. No. 14033, line 2 should read: CLADDING TUBES. Verstappen, G.; Deknock, R.; Neider,

NSA Vol. 20, No. 24, Abst. No. 46753, line 5 should read: (Oct. 3, 1966). (UCRL-14927(Rev. 3)).

NSA Vol. 21, No. 2, Abst. No. 2619, line 4 should read: lin, Walter. Nucl. Phys., A90: 339-52(1967). (COO-7-400).

NSA Vol. 21, No. 4, Abst. No. 5584, line 4 should read: 937, Nucl. Phys., A91: 433-8 (1967). (PUC-937-214).

NSA Vol. 21, No. 6, Abst. No. 9979, line 5 should read: Nucl. Phys., A93: 648-72 (1967). (UCRL-14629(Rev. 2)).

NSA Vol. 21, No. 6, Abst. No. 9799, line 5 should read: (UCRL-16812(Rev.)).

NSA Vol. 21, No. 9, Abst. No. 14443, line 4 should read: Phys., 12: 1609-16(Nov. 1966). (UCRL-14415(Rev. 1)).

NSA Vol. 21, No. 11, Abst. No. 18961, line 4 should read: (Feb. 25, 1967). (COO-264-335(Rev.)).

NSA Vol. 21, No. 12, Abst. No. 21217 line 4 should read: (10), 48A: 587-8(Mar. 21, 1967). (UCR-34-P-107-38).

NSA Vol. 21, No. 13, Abst. No. 23723, lines 3 and 4 should read: CHETTE TYPE Si-23. (SILOE: Calculation of Pressure Drop in the Si-23 Fork-Type Control Rods). Merchie, F. (Commissariat

NSA Vol. 21, No. 13, Abst. No. 23530, line 4 should read: 1967). (UCRL-70062 (Rev.1)).

NSA Vol. 21, No. 15, Abst. No. 27574, line 1 should read: (NYO-GEN-72-132) PEGRAM NUCLEAR PHYSICS LAB-

NSA Vol. 21, No. 15, Abst. No. 27118, line 9 should read: JCL $1.60 fs, $0.80 mf.

NSA Vol. 21, No. 16, Abst. No. 29949, line 4 should read: (Apr. 20, 1967). (UCRL-70101(Rev. 1)).

NSA Vol. 21, No. 17, Abst. No. 31474, line 4 should read: Contract W-7405-eng-26. 36p. (CONF-670602-12). Dep.

NSA Vol. 21, No. 18, Abst. No. 34003, line 2 should read: 102 with mass numbers 255 and 256 in reactions with oxygen ions.

NSA Vol. 21, No. 22, Abst. No. 41957, add the following to the last line of abstract: ... that the process responsible for the loss of electrons is continuous, relative to the Pegasus orbital time. (auth)

NSA Vol. 21, No. 9, Abst. No. 14157, line 6 should read: by distillation with HCl/HBr as a specific separation method,

NSA Vol. 21, No. 9, Abst. No. 14269, line 10 should read: $HNO_3 \rightarrow NO_3 + H_2O$ and not by the reaction $OH + NO_3^- \rightarrow OH^- + NO_3$

NSA Vol. 21, No. 10, Abst. No. 15895, line 16 should read: found in all samples. The thermodynamically unstable CR(III)

NSA Vol. 21, No. 10, Abst. No. 16356, line 48 should read: osteoporotic signs are present; between 0.1 and 0.05 $\mu$g Ra (PRE)

NSA Vol. 21, No. 10, Abst. No. 16795, line 16 should read: of Barnett and Ray, and McClure for the dissociation of $H_2^+$ in hydro-

NSA Vol. 21, No. 11, Abst. No. 17615, line 8 should read: $(CONH_2NH_3)_2UO_4$. A similar complex with methylurea was ob-

NSA Vol. 21, No. 11, Abst. No. 18391, line 11 should read: band 11 to 25 Å. The line identifications obtained are given,

NSA Vol. 21, No. 11, Abst. No. 18474, line 4 should read: Labs., Jodrell Bank, Eng.). Nature, 213: 1107(March 18, 1967)).

NSA Vol. 21, No. 11, Abst. No. 19404, line 4 should read: closed-cycle MHD generator coupled to a HTGC reactor. The

NSA Vol. 21, No. 12, Abst. No. 19570, line 6 should read: haemoglobin was investigated. The determination of Co by neutron acti-

NSA Vol. 21, No. 12, Abst. No. 20602, line 9 should read: growth, $\alpha$-$Al_2O_3$ single crystals irradiated to various doses in the range $5 \times 10^{19}$ to $4 \times 10^{20}$ nvt $\geq$ 1 MeV at 150, 650, and 1,000°C, re-

NSA Vol. 21, No. 12, Abst. No. 21504, lines 12 and 13 should read: surements of $^{54}Fe$, $^{58}Ni$ and $^{32}S(n,p)$ and $^{27}Al(n,\alpha)$ differential cross sections is made in order to calculate the fission-neutron spectrum

NSA Vol. 21, No. 12, Abst. No. 21682, line 25 should read: direct determination of rating distribution by activation of stainless

NSA Vol. 21, No. 13, Abst. No. 21925, line 12 should read: rium, cerium and nickel of compositions $Th(SO_4)_2 \cdot 2N_2H_4$, $Ce(SO_4)_2 \cdot$

NSA Vol. 21, No. 13, Abst. No. 21925, line 16 should read: complexes with the metallic sulphates are discussed. (auth)

NSA Vol. 21, No. 13, Abst. No. 22057, line 12 should read: syenites. Also $^{18}O/^{12}C$ ratios relative to the Chicago PDB stan-

NSA Vol. 21, No. 14, Abst. No. 24818, line 9 should read: not detectably altered for doses up to 100 $\mu$A-min. Doses above 10

NSA Vol. 21, No. 14, Abst. No. 25087, line 11 should read: each with the A15 structure, in the interval $0.3 < x < 0.8$. Whereas

# CORRECTIONS

NSA Vol. 21, No. 2, Abst. 2617, line 3 should read: Univ., Jerusalem). Nucl. Phys., A90: 459-72(1967).

NSA Vol. 21, No. 2, Abst. 2618, line 3 should read: Washington, D. C.); Traechslin, Walter. Nucl. Phys., A90: 334-

NSA Vol. 21, No. 2, Abst. 2619, line 4 should read: lin, Walter. Nucl. Phys., A90: 339-52(1967).

NSA Vol. 21, No. 2, Abst. 2676, line 3 should read: Phys., A90: 311-20(1967).

NSA Vol. 21, No. 2, Abst. 2697, line 4 should read: Nucl. Phys., A90: 321-33(1967).

NSA Vol. 21, No. 2, Abst. 2698, line 3 should read: chester, Eng.). Nucl. Phys., A90: 379-400(1967).

NSA Vol. 21, No. 2, Abst. 2699, line 4 should read: A90: 473-9(1967).

NSA Vol. 21, No. 2, Abst. 2733, line 3 should read: Michiaki (Tokyo Univ.). Nucl. Phys., A90: 253-60(1967).

NSA Vol. 21, No. 2, Abst. 2776, line 3 should read: London). Nucl. Phys., A90: 289-310(1967).

NSA Vol. 21, No. 2, Abst. 2778, line 3 should read: A90: 241-52(1967).

NSA Vol. 21, No. 2, Abst. 2780, line 2 should read: Hoegaasen, J. (CERN, Geneva). Nucl. Phys., A90: 261-88

NSA Vol. 21, No. 2, Abst. 2810, line 4 should read: Phys., A90: 449-58(1967).

NSA Vol. 21, No. 2, Abst. 2811, line 3 should read: Swan, Peter (Univ. Laval, Quebec). Nucl. Phys., A90: 436-48

NSA Vol. 21, No. 2, Abst. 2812, line 4 should read: Stockholm). Nucl. Phys., A90: 401-6(1967).

NSA Vol. 21, No. 2, Abst. 2813, line 3 should read: (Los Alamos Scientific Lab., N. Mex.). Nucl. Phys., A90:

NSA Vol. 21, No. 2, Abst. 2814, line 3 should read: A90: 412-22(1967).

NSA Vol. 21, No. 2, Abst. 2815, line 3 should read: Laval, Quebec). Nucl. Phys., A90: 423-35(1967).

NSA Vol. 21, No. 2, Abst. 2816, line 3 should read: of Auckland, N. Zeal.). Nucl. Phys., A90: 353-60(1967).

NSA Vol. 21, No. 2, Abst. 2817, line 3 should read: Eng.). Nucl. Phys., A90: 361-78(1967).

# SPECIAL NOTICE

Several important changes to *Nuclear Science Abstracts (NSA)* have been made beginning with Volume 21.

1. Page size has been increased to $8\frac{1}{2}'' \times 11''$ for reasons of printing economies.
2. The indexes are being prepared by computer.
3. Extensive subcategorization has been developed for all abstract categories.
4. Important revisions and restructuring of main subject headings (with appropriate cross references) have been made in the general areas of Physics, Biology and Medicine, and Organic Chemistry. These changes will be reflected in a new edition of TID-5001, "Subject Headings Used by the USAEC Division of Technical Information," soon to be issued.

Another important fact concerning *NSA* is that there will be no annual index issued for Vol. 20. There will be a fourth-quarter index. A five-year cumulative subject, personal author, and corporate author index covering Vols. 16-20 will be issued during 1967. A cumulative report number index for Vols. 16-20 will be issued early in 1967.

This issue contains a list of currently scanned journals plus the various categories and subcategories used in defining the subject scope of *NSA*.

Volume 21, Number 1 January 15, 1967

# NUCLEAR SCIENCE ABSTRACTS

# CHEMISTRY

## Analytical Chemistry

*Refer also to abstract 628.*

**1** (AD–635692) NEUTRON ACTIVATION ANALYSIS. Progress Report. Glass, A. L.; Tankins, Edwin S. (Naval Air Engineering Center, Philadelphia, Pa. Aeronautical Materials Lab.). May 24, 1966. 10p. (PR–1). CFSTI $1.00 cy, $0.50 mn.

The object of the initial phase of the investigation was to obtain and install a system with adequate shielding for neutron activation analysis and to provide the additional laboratory facilities for its use. A description of the equipment obtained, with the shielding that was erected, is given. (auth)

**2** (AE–247) NEUTRON-ACTIVATION ANALYSIS OF BIOLOGICAL MATERIAL WITH HIGH RADIATION LEVELS. Samsahl, K. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Sept. 1966. 15p. Dep. mn.

A method has been developed for the chemical separation and subsequent gamma-spectrometric analysis of the alkali metals, alkaline earths, rare earths, chromium, hafnium, lanthanum, manganese, phosphorus, scandium, and silver in neutron-activated biological material. The separation steps, being fully automatic, are based on a combination of ion exchange and partition chromatography and require 40 min. (auth)

**3** (AERE-R–5253) A RAPID TRACER METHOD FOR THE DETERMINATION OF RADIOLYTIC CARBON DIOXIDE BY GAS COUNTING. Hills, P. R.; Restall, S. W. F. (Research Group, United Kingdom Atomic Energy Authority, Wantage (England)). Sept. 1966. 14p. Dep. mn. BIS $0.50. HMSO 2s. 6d.

A method was developed for estimating small amounts of carbon dioxide produced in liquid systems during the radiolysis of $^{14}C$-labeled compounds. Carbon dioxide was swept from the reaction vessel in a suitable gas stream, condensed, and counted internally in a Geiger counter. The method can follow rapid changes in carbon dioxide evolution. In order to obtain absolute radiolytic yields, the activity of solutions before radiolysis was determined by a combustion flask technique, modified so that the samples are burnt in a stream of oxygen. The technique is rapid and reproducible. The conditions under which such an estimation method might be applied to the evaluation of radioactive paper chromatograms were determined. (auth)

**4** (AI-CE–35) HEAVY WATER ORGANIC COOLED REACTOR. GAMMA-GAMMA COINCIDENCE COUNTING APPLIED TO CHLORINE ANALYSIS BY NEUTRON ACTIVATION. Bramlitt, E. T. (Atomics International, Canoga Park, Calif. Combustion Engineering, Inc., Windsor, Conn.). Sept. 30, 1966. Contract AT(38-1)-430. 28p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Gamma-gamma coincidence techniques for radionuclide determination have been shown to facilitate activation analysis. A routine neutron activation method for determining trace quantities of chlorine in organic coolants has been developed which eliminates the effect of interfering impurity activities. The method has significantly extended the experimental sensitivity for chlorine detection to about 10 ppB and at the same time has improved the precision and accuracy of the determination. (auth)

**5** (EUR–3072.i) DETERMINAZIONE DI TRACCE DI OSSIGENO NEL PIOMBO. (Determination of Oxygen Traces in Lead). Serrini, G.; Leyendecker, W. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1966. 14p. Dep. mn.

The trace determination of oxygen in lead is described. Oxygen after reduction by hydrogen at 700°C is transformed in water-steam, which is quantitatively absorbed and titrated by K. Fischer's reagent. The detection limit is 0.6 ppM oxygen. The coefficient of variation of the method is less than 15% at levels between 1.5 and 32 ppM oxygen. Well-known amounts of PbO are found quantitatively. With this technique, 3–4 determinations a day are possible. (auth)

**6** (EUR–3077.i) DETERMINAZIONE DELL'OSSIGENO NEGLI OSSIDI REFRATTARI COL METODO AL MONOCLORURO DI ZOLFO. (Determination of Oxygen Content of Refractory Oxides by the Sulphur Monochloride Method). Gigli, G. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1966. 26p. Dep. mn.

The $S_2Cl_2$ method has been applied to the determination of oxygen in the refractory oxides: $ZrO_2$, MgO, $Al_2O_3$. Utilizing the synthetized reagent freshly prepared and HgS as absorbent of $S_2Cl_2$ excess vapors, the results obtained have been satisfactory. Reaction temperature has been consistent at 900°C. The total standard deviation for the 3 oxides calculated over 26 determinations is ±0.90 for oxygen content between 25 and 50% and for sampling of 20–35 mg. The obtained sensitivity limit is 70 μg oxygen per hour for a flow of inert gas of 1.4 liters per hour and for temperatures of the reagent in its container, near to its boiling point. This method has been applied with good results for the resolution of analytical problems presented by certain particular SAP types, with high contents of combined N, up to 2% and not readily attacked by gaseous HCl at 400°C: for such SAP types the residue of the attack by gaseous HCl is completely volatilized at 900°C by means of $S_2Cl_2$ vapors. The method is, therefore, advantageous, because, if not a substitutive one of gaseous HCl method, it is at least a good integrative one of the same method for $Al_2O_3$ determination in SAP. (auth)

**7** (MCW–1495) A DIRECT SPECTROMETRIC DETERMINATION OF Dy, Eu, Gd, AND Sm IN HIGH-PURITY THORIUM DIOXIDE. Nelms, J. R.; Vogel, R. S. (Mallinckrodt Chemical Works, Weldon Spring, Mo. Ura-

nium Div.). Aug. 1, 1966. Contract W-14-108-eng-8. 11p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

An emission spectrometric method was developed for the direct determination of Dy, Eu, Gd, and Sm in the ppM range in high-purity thorium dioxide. The procedure, based on a carrier-distillation technique, utilizes silver chloride as a carrier with neodymium as an internal standard. Excitation in an atmosphere of 80% argon–20% oxygen prevents formation of cyanogen band-spectra and thereby permits the use of sensitive lines in the regions normally obscured by cyanogen bands. The method fulfills the requirements of precision and sensitivity for specification analysis of reactor-grade thorium dioxide with time savings of approximately 60% compared to conventional methods involving chemical separation. (auth)

**8** (MCW–1498) A SPECTROCHEMICAL METHOD FOR THE DETERMINATION OF INDIVIDUAL RARE EARTH ELEMENTS IN URANIUM ORE CONCENTRATES AND HIGH-PURITY URANIUM COMPOUNDS. Vogel, R. S.; Dubowski, T. F.; Nelms, J. R.; Sheller, A. L. (Mallinckrodt Chemical Works, Weldon Spring, Mo. Uranium Div.). Jan. 19, 1966. Contract W-14-108-eng-8. 14p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A method is described for the determination of specific rare earth elements in uranium ore concentrates and high-purity uranium compounds. The method involves a preliminary chemical concentration of the rare earth elements, followed by a spectrographic analysis of the rare earth concentrate by direct-current excitation, using neodymium as an internal standard. In the preliminary chemical concentration, uranium is removed by extraction with tri-n-butyl phosphate (TBP). The rare earths as well as other insoluble hydroxides are then precipitated by ammonium hydroxide. Residual uranium is removed by a second ammonium hydroxide precipitation in the presence of ethylenediamine tetraacetic acid (EDTA), which forms a soluble rare earth complex. The rare earths are then precipitated as oxalates and ignited to oxides. The rare earth concentrate is then analyzed spectrographically by d-c arc excitation and densitometric methods. The calibrated analytical range for a given element is 1 ppB to 100 ppM on a sample basis. The average precision of a single determination is 22% (relative) at the 95% confidence level. (auth)

**9** (MCW–1499) ALKALINE-PEROXIDE COLORIMETRIC METHODS FOR THE DETERMINATION OF URANIUM. Waldron, H. F. (Mallinckrodt Chemical Works, Weldon Spring, Mo. Uranium Div.). Aug. 1, 1966. Contract W-14-108-eng-8. 63p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

A comprehensive review of the literature on the determination of uranium by measuring the absorbance of the uranium peroxide species in an alkaline medium is presented. The factors affecting the accuracy and precision of the measurement are discussed according to whether sodium carbonate, sodium carbonate and sodium hydroxide, sodium hydroxide, or other reagents are used to supply the alkaline medium. The sodium hydroxide system is concluded to be the best for general applications. In all but some special situations, 400 mμ is the optimum wavelength for measuring the uranium peroxide color. Increased sensitivity can be obtained at shorter wavelengths, but the loss of accuracy and/or the necessity for close pH and reagent concentration control nullifies the advantage. Longer wavelengths yield reduced sensitivity with no compensation. The sodium hydroxide system is the most rugged and permits complete standardization of reagent volumes without previous measurements and/or adjustments. The high pH provides better spectral absorbance characteristics and higher tolerance levels of molybdenum, thorium, vanadium, and zirconium than the other systems. The sodium carbonate system requires more operator care, but it is less sensitive to the presence of arsenic, barium, cerium, cobalt, iron, magnesium, manganese, nickel, silicon, tin, and titanium. The higher permissible levels for the elements that precipitate in an alkaline medium are due to less uranium occlusion in the presence of carbonate. To a large extent, this advantage may be obtained in the sodium hydroxide system if the peroxide is added before the solution is made alkaline. When the system contains both sodium hydroxide and sodium carbonate, the spectral absorbance characteristics approach those of the sodium hydroxide system while the interferences become similar to those of the sodium carbonate system. In comparison to the sodium hydroxide system, however, considerably more caution is required to obtain reliable results. A comparison of interferences in the three major systems is shown. (auth)

**10** (MCW–1507) SPECIFICATIONS TESTING MANUAL. Speer, Mary Anne; Springgate, R. T. (eds.) (Mallinckrodt Chemical Works, Weldon Spring, Mo. Uranium Div.). Sept. 1966. Contract W-14-108-eng-8. 572p. Dep. mn. CFSTI $6.00 cy, $2.50 mn.

Specification procedures that have been or are being used for the sampling and testing of feed materials, process chemicals, products, and waste streams at the Feed Materials Plant operated by the Uranium Division of Mallinckrodt Chemical Works are compiled. The procedures were designed for the particular materials received or resulting from operation at the site. Individual sections included procedures for the analysis of: uranium ore concentrates; uranium trioxide; uranium dioxide; uranium tetrafluoride; uranium metal; spectrochemical uranium samples; thorium oxide; process chemicals; and waste streams. (P.C.H.)

**11** (NYO–4700(Rev.)(Suppl.3)) MANUAL OF STANDARD PROCEDURES. (Health and Safety Lab., New York Operations Office (AEC), N. Y.). Sept. 1966. 57p. Dep. CFSTI $3.00 cy, $0.75 mn.

Additions and corrections made to the Health and Safety Laboratory Manual of Standard Procedures include: chemical procedures; fallout methods; specifications; semiconductor detectors; $\alpha$ and $\beta$ emitters; and aerosol properties. (M.C.G.)

**12** (UCID–15014) ANALYTICAL SECTION QUARTERLY REPORT, APRIL 1–JULY 31, 1966. Harrar, J. E. (comp. and ed.) Lawrence Radiation Lab., Univ. of California, Livermore). Aug. 4, 1966. Contract W-7405-eng-48. 38p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Research is reported on: determination of carbon and sulfur in refractory metals; inert gas fusion; vacuum fusion; determination of oxygen in LiH and LiD; modifications of the coincident field mass spectrometer; automation of the CEC 21-103C mass spectrometer; a field operational differential mass spectrometer; gas chromatography data acquisition; reduction of mass spectrometer data; computer programs for spectrophotofluorimetry; processing of emission spectra data; determination of metallic impurities in Ta, W, Mo, and Re; spectroscopy of the actinides; x-ray fluorescence, spectrophotofluorimetry; determination of alkali metal impurities in Cs and Rb; determination of trace W in Ag; trace fluoride analysis; determination of trace cerium in solutions of biological origin; determination of milligram amounts of tin; differential polarography; controlled-potential coulometers; chemical reactivity; inorganic synthesis; determination of trace impurities in gases; a helium densitometer; helium carrier gas purification; and automatic apparatus for determination of He diffusion rates. (M.C.G.)

**13** SEPARATION OF RARE EARTH ELEMENTS USING DI-(2-ETHYL HEXYL)ORTHO PHOSPHORIC ACID AND MONO-(2-ETHYL HEXYL)ORTHO PHOSPHORIC ACID MIXTURES. Tsubota, Hiroyuki (Tokyo Univ.); Watari, Kazuo. Nippon Kagaku Zasshi, 87: 1106-7(Oct. 1966). (In Japanese).

The influence of the ratio of di-(2-ethyl hexyl)ortho phosphoric acid (HDEHP) and mono-(2-ethyl hexyl)ortho phosphoric acid ($H_2EHP$) in mixed reagent on extracting rare elements from nitric acid solution was studied. The distribution coefficient of each rare earth element increases as $H_2EHP$ content increases. Batch and counter current methods gave distribution coefficients which agreed with those calculated. The results showed that the mixed re-

agent can be used for the separation of rare earth elements. (auth)

**14** PHOTOACTIVATION OF GALLIUM, INDIUM, AND THALLIUM BY 15 Mev BREMSSTRAHLUNG AND THE USES OF THE PRODUCTS IN ACTIVATION ANALYSIS. Oka, Yoshinaga; Kato, Toyoaki (Tohoku Univ., Sendai). Nippon Kagaku Zasshi, 87: 1057-60(Oct. 1966). (In Japanese).

The advantages of the use of 15 MeV bremsstrahlung radiation in activation analyses of gallium and thallium in indium matrix, and thallium in gallium–indium mixtures are discussed. Individual metals and synthetic mixtures of gallium–indium–thallium in different mixing ratio were irradiated for 1 hr, and the photopeaks of 0.511 MeV $\gamma$ ray of $^{68}$Ga and of 0.439 MeV $\gamma$ ray of $^{202}$Tl were measured. The matrix indium was used as an internal monitor of bremsstrahlung dose rate, and the radioactivities of the residual $^{114m}$In were estimated by its 0.190 MeV $\gamma$ photopeak. Sensitivities of about 20 $\mu$g for gallium and about 10 $\mu$g for thallium in the indium matrix were obtained. One tenth per cent thallium content or less in the gallium matrix was found to be determinable by this method. (auth)

**15** EXCLUSION OF DISTURBING EFFECTS DUE TO ORGANIC MATTER IN DETERMINATIONS OF URANIUM BY THE PEROXIDE METHOD. Upor, Endre; Goerbicz, Laszlone; Novak, Gyozo. Magyar Kem. Lapja, 21: 487-8(Sept. 1966). (In Hungarian).

A significant positive error inherent in the determination of uranium in industrial liquors containing carbonates was found due to the organic matter present. This source of error can be eliminated by boiling the sample solution with potassium permanganate prior to analysis. Organic matter also leads to erroneous results when the analysis utilizes the light absorption of the $[UO_2(CO_3)]^{4-}$ ions. (auth)

**16** QUANTITATIVE DETERMINATION OF THORIUM AND SCANDIUM WHEN PRESENT SIMULTANEOUSLY. Kostin, N. V.; Vargina, R. V. Vestn. Moskov. Univ., Ser. II: Khim., No. 3, 45-6(May-June 1965). (In Russian).

m-Fluorobenzoic acid was investigated as an agent for separating scandium and thorium. It precipitates quantitatively all of the thorium contained in neutral or slightly acid solutions of the two elements without interfering with the subsequent complexometric determination of scandium in the filtrate. The $Th(C_6H_4FCOO)_4$ precipitate settles easily. In order to avoid splattering of the molten precipitate when transforming it into thorium oxide for gravimetric determination, oxalic acid crystals are added before calcining at 500 to 600°C. The scandium is determined in the filtrate by titration with Trylone B, using Xylenol Orange indicator. (TTT)

**17** ANALYTICAL METHOD BASED ON ISOTOPIC DILUTION OF A RADIOACTIVE MATERIAL. II. Klas, Jan (Slovak Polytechnic Inst., Bratislava). Chem. Zvesti, 20: 530-7(1966). (In Czech).

Analytical evaluation of the Block–Anker and Limakov–Rozavskij double isotopic dilution method indicated a higher accuracy of the single isotopic dilution method. Equations describing relative incongruencies in the analysis are given and some simplifications and corrections are suggested. (R.V.J.)

**18** STUDIES OF THE ABSORPTION CURVES OF VARIOUS MIXTURES OF $^{24}$Na–$^{42}$K FOR CONTROLLING RADIOCHEMICAL PURITY IN NEUTRON ACTIVATION ANALYSIS. Rakovic, Miloslav; Prochazkova, Z. (Charles Univ., Prague). Chem. Zvesti, 20: 538-44(1966). (In Czech).

Absorption curves for mixtures of $^{24}$Na and $^{42}$K were calculated for the cases in which the pulse rate (measured without filter) was caused chiefly by one radionuclide and the second participated only to 2, 4, 6, or 10% of the pulse rate. The effects of an aluminum filter were studied. The method makes it possible to control the impurities of $^{42}$K in $^{24}$Na and of $^{24}$Na in $^{42}$K. (M.C.G.)

**19** SPECTROGRAPHIC DETERMINATION OF HYDROGEN IN ALLOYS OF ZIRCONIUM. Rossi, G.; Hainski, Z. (Euratom–CCR, Ispra, Italy). Met. Ital., 58: 290-4(Aug. 1966). (In Italian).

The application of Fassel's method to determine gases in Zircaloy was previously described. Graphite and hydrides of zirconium were used as standard samples to construct the working curve. Nevertheless the analytical results obtained on the basis of this curve systematically gave values too low. The extraction of hydrogen from metal samples and the influence on the extraction and the following excitation of such parameters as sample temperature during the arc discharge, inert gas pressure in the excitation chamber, and the electrode shape were studied. The results indicated that to obtain a complete extraction and a maximum emission, it is necessary to reach the metal melting and the hydrogen excitation during its development. This way the sensitivity of the method is increased since it is possible to determine 2 $\mu$g of hydrogen in samples of 100 to 200 mg. The results obtained with graphite and Zr hydride tablets align perfectly on the working curve plotted starting from Zircaloy samples of known hydrogen content. This method applies to other metals and alloys and can be used for routine analysis as a substitute for vacuum extraction methods. The eventual use of a direct reading system to reduce the analysis time and to increase the sensitivity considerably could eliminate errors caused by the plate thus improving accuracy. (auth)

**20** ALPHA-SPECTROMETRIC ISOTOPIC FREQUENCY ANALYSIS OF URANIUM. Merz, E.; Kirchner, H. (Kernforschungsanlage, Juelich, Ger.). Nukleonik, 8: 241-4(June 1966). (In German).

Nuclear technology frequently requires the accurate knowledge of the isotopic composition of U. Since almost all U isotopes are $\alpha$-unstable, an isotope frequency analysis can be carried out by $\alpha$ spectrometry in certain cases. The sensitivity of this method is not too high, but it is sufficiently accurate in many cases and it has the advantage of simplicity. By use of a lattice ionization chamber systematic investigations on the possibilities and limits of $\alpha$ particle counting for isotope frequency analysis were made. The methods for preparation of thin counting preparations and the effect of materials and surface condition of the support were tested extensively. The best energy resolution was given by vacuum evaporation of uranium oxide on a polished Pt foil. (tr-auth)

**21** LOW TEMPERATURE IRRADIATION APPLIED TO NEUTRON ACTIVATION ANALYSIS OF MERCURY IN HUMAN WHOLE BLOOD. Brune, Dag (Aktiebolaget Atomenergi, Studsvik, Sweden). Acta Chem. Scand., 20: 1200-2(1966). (AE-213).

Distribution of mercury in human whole blood was studied by means of neutron activation analysis. During irradiation samples were kept at low temperature to prevent interferences by volatilization and contamination. The mercury activity was separated by means of distillation and ion exchange techniques. A standard deviation of ±7% was obtained. (auth)

**22** THE INFLUENCE OF DILUENT ON THE EXTRACTION FROM SULFURIC ACID OF URANIUM (IV) AND (VI) BY N-DECYLANILINE. Zvyagintsev, O. E.; Frolov, Yu. G.; Sergievskii, V. V.; Huang, Chung. Zh. Neorg. Khim., 11: 661-5(Mar. 1966). (In Russian).

Studies were made on the influence of additions and the concentration of n-octyl and isooctyl alcohols, oleic acid, chloroform, and nitrobenzene on the extraction from sulfuric acid of uranium and uranyl sulfates by N-decylaniline. An increase of extraction with the diluent series: n-octane < nitrobenzene < chloroform < isooctyl alcohol < n-octyl alcohol < oleic acid was found. It was also found that extraction of uranium and uranyl sulfates is accompanied by an additional acid extraction. Cryoscopic analysis indicated the N-decylaniline sulfates with two n-octyl alcohol molecules with stability constant equal to 200 ± 50. (tr-auth)

**23** CONDUCTOMETRIC STUDY ON THE QUANTITATIVE PRECIPITATION OF LANTHANUM AND NEODYMIUM AS NORMAL TELLURITES. Prasad, Sarju; Pathak, K. C. (Banaras Hindu Univ., Varanasi, India). J. Electroanal. Chem., 12: 360-2(Oct. 1966).

The conductometric titrations of lanthanum and neodymium nitrates with sodium tellurite were studied as a possible analytical method for the determination of lanthanum and neodymium as the normal tellurites. Additions to the aqueous media of 15% ethanol by volume for lanthanum and 25% for neodymium gave the best results. The reproducibility and accuracy of the method are excellent even at low concentrations. (J.G.B.)

**24** SPECIFICITY OF RADIOCHEMICAL DETERMINATION OF LOW-LEVEL ACTIVITIES. Knezevic, Zvonko; Pujic, Zdravko. Glasnik Hemicara Tehnol. Bosne Hercegovine, 12: 121-30(1963). (In Croatian).

A review of various methods for determining the specificity of radiochemical activity in environmental samples is presented. Problems arising from the statistical treatment of the experiments are considered along with the chemical separation of radionuclides, the means of obtaining environmental and laboratory samples, the necessary corrections for experiments on the isotopic content of aerosol probes, and some problems on the specificity of radiochemical determination of low-level $^{14}C$ activity for age estimation. The identification of individual radionuclides using fission curves, gamma spectroscopy, multiple separation and absorption curves is also discussed. Various means of improving on these techniques are also given. (G.O.Y.)

**25** RADIOMETRIC DETERMINATION OF SULFUR IN LIQUIDS AND GASES. DETERMINATION OF SULFUR IN LIQUID. Lyast, I. Ts.; Vshivtsev, A. D. Khim. Seraorgan. Soedin., Soderzhashch. v Neft. i Nefteprod., Akad. Nauk SSSR, Bashkirsk. Filial, 7: 227-32(1964). (In Russian).

Sulfur is determined radiometrically from the absorption of soft $\gamma$-radiation of an $^{55}Fe$ or tritium source. One beam is sent through a container with the sulfur compound, and another beam is sent through a compensating wedge. The difference current is amplified and modified to give direct readings of the sulfur content on a microammeter. The angle of rotation of the wedge is proportional to the absorption ability of the sulfur compound. The ionization chamber is filled with argon gas to obtain a maximum ionization current, which increases by a factor of 2.2, 3.5, and 8 for chamber volumes of 5.0, 1.4, and 0.35 l respectively, when compared to counting in air. The chamber is 8 cm in dia and 10 cm high. Sulfur contents can be measured in the range of 0.1 to 2.0% with a measurement error of ±0.01% in benzene, kerosene, or diesel oil fuel. The analysis requires 3 to 4 min. The source activity is 1 to 5 mCi. A $^{90}Sr$ source is also included in the unit along with an $^{55}Fe$ source in order to determine the composition of carbon and hydrogen in hydrocarbon products. The mass absorption coefficient by a photoelectric mechanism increases with the fourth power of the atomic number of the absorber. (TTT)

**26** SPECTROPHOTOMETRIC STUDY OF REAGENTS FOR DETERMINATION OF YTTERBIUM. Babko, A. K.; Akhmedli, M. K.; Granovskaya, P. B. (Inst. of General and Inorganic Chemistry, Academy of Sciences, Ukrainian SSR. Azerbaidzhan State Univ., USSR). Ukr. Khim. Zh., 32: 879-85(1966). (In Russian).

Comparative studies of 16 organic reagents forming colored compounds with rare earth elements of the Yb subgroup were made on Yb samples. Absorption spectra of the molecular and ion forms of the reagents and their complexes with Yb were taken. The composition of the complex compounds were determined. The best reagents for spectrophotometric determination of the rare earth elements of the Yb subgroup were Arsenazo(III), Xylenol Orange, Stilbazo, Methylthymol Blue, and Pyrocatechin Violet. (tr-auth)

**27** DETERMINATION OF YTTRIUM AND BERYLLIUM IN COMPLEX SYSTEMS BY MEANS OF COMPLEXONOMETRIC TITRATION. Borzenkova, M. P. Vestn. Moskov. Univ., Ser. II, Khim., No. 1, 50-3(Jan.-Feb. 1966). (In Russian).

The difference in complex stability was used to determine yttrium in the presence of beryllium by titrating with Trilon B. An excess of 0.01M Trilon B solution was added to the aliquot solution of $Y^{3+}$ and $Be^{2+}$ in order to tie up the cations in complex form. Beryllium was completely precipitated as $Be(OH)_2$ by adding ammonia (1:1). The excess Trilon B was titrated with a 0.01M $ZnCl_2$ solution in the presence of the $Be(OH)_2$ precipitate with erochrome black T as an indicator. The yttrium analyses were satisfactory. Beryllium was determined gravimetrically by filtering off the $Be(OH)_2$ precipitate, firing, and weighing as BeO. Satisfactory results for beryllium were obtained with a content of 50 to 140 mg BeO in solution. (TTT)

**28** DETERMINATION OF THE URANIUM–OXYGEN RATIO IN URANIUM OXIDE BY COULOMETRIC ANALYSIS WITH CONTROLLED POTENTIAL. Koshcheev, G. G.; Rachev, V. V.; Ippolitova, E. A.; Zhelankin, A. V. Vestn. Moskov. Univ., Ser. II, Khim., No. 1, 54-6(Jan.-Feb. 1966). (In Russian).

Uranium oxides were dissolved in concentrated $H_3PO_4$, and nitrogen was passed through the heated solution to displace oxygen. Ten ml of 1.0M $H_2SO_4$ and 3 ml of Hg were placed in the cathode section of the electrochemical cell. One to 2 ml of sample solution with a total U content of 0.3 to 1 mg was added. U(VI) was reduced to U(IV) at a cathode potential $\phi = -0.24$ volts for 3 to 4 min. The current strength was noted each 15 to 30 sec. The total amount of uranium was determined by oxidizing U(IV) to U(VI) with the addition of double the stoichiometric amount of Ce(IV) at a cathode potential $\phi = -0.05$ volts. The excess Ce(IV) was also reduced at this same potential. The U(VI) was reduced to obtain the total uranium. The O/U ratio was calculated from the relation: $O/U = 2.000 + U(VI)/U_{tot.}$ The accuracy in determining the O/U ratio was ±0.005. (TTT)

**29** VARIOUS SPECTROPHOTOMETRIC MEASUREMENTS FOR DETERMINING ERBIUM IN HOLMIUM AND THULIUM AND YTTERBIUM IN LUTETIUM. Romantseva, T. I.; Gromova, M. I.; Peshkova, V. M. Vestn. Moskov. Univ., Ser. II, Khim., No. 1, 73-8(Jan.-Feb. 1966). (In Russian).

The absorption spectra of water-alcohol solutions of Er, Ho, Tm, Yb, and Lu complexes with 7-iodo- 8-hydroxyquinoline–5-sulfonate were investigated. A fourfold amount of reagent was added, and the pH was adjusted with ammonia. Er showed a high difference in optical densities at $\lambda = 519$ mμ and $\lambda = 525$ mμ ($\Delta\epsilon = 15.5$) at a pH of 10.5 in perchlorate solution, while this difference was small for Tm ($\Delta\epsilon = 0.5$) and Ho ($\Delta\epsilon = 1.3$). Thus, Er could be determined in the presence of Tm or Ho. Similarly it was also possible to determine Yb in the presence of Lu by measuring the difference in optical densities at $\lambda = 960$ and $\lambda = 980$ mμ in a water-alcohol (3:2) solution having a pH of 7.3. (TTT)

**30** DETERMINATION OF THE $^{99m}Tc$ ACTIVITY. Stephan, H. Isotopenpraxis, 2: 234-5(June 1966). (In German).

A method for the measurement of the $^{99m}Tc$ activity, based on the Smith method, was developed for routine uses. The method is based on a comparison of the 140- and 142-keV $\gamma$ radiation of $^{99m}Tc$ with the 123- and 137-keV $\gamma$ radiation of $^{57}Co$, using a NaI(Tl) crystal for detection. The radioactive impurities of $^{99m}Tc$ were determined by a second measurement in an 8-mm thick lead absorber. Ionization chamber measurements were compared with $\gamma$ spectrometer measurements and the results showed that, without correction, ionization chamber measurements using $^{60}Co$ as the comparison isotope gave values too high and $^{57}Co$ as the comparison isotope gave values too low. (J.S.R.)

**31** SPECTROPHOTOMETRIC DETERMINATION OF NEODYMIUM IN THE PRESENCE OF PRASEODYMIUM

AND SAMARIUM. Romantseva, T. I.; Gromova, M. I.; Peshkova, V. M. Vestn. Moskov. Univ., Ser. II: Khim., No. 6, 74-8(Nov.-Dec. 1965). (In Russian).

In order to improve the sensitivity of spectrophotometric determination of rare earth elements, the absorption spectra of complex compounds of neodymium, praseodymium, and samarium with 7-iodo-8-oxyquinoline-5-sulfonic acid was investigated. The complexes were prepared by adding a solution of the reagent in alcohol and water to an aqueous solution of the rare earth perchlorates. It was found that absorption at the characteristic maximum of neodymium ($\lambda$ = 581 m$\mu$) is enhanced by the complexing action, thus improving the sensitivity of the determination and making it possible to carry out the analysis in the presence of large amounts of praseodymium and samarium. When determining neodymium in neodymium–praseodymium systems, it was found that in the pH = 8.0 to 11.0 range, the absorption of the complex remains constant while that of the reagent decreases sharply. If the total rare earth concentration does not exceed $3 \times 10^{-3}$ M, the method developed allows determination of neodymium in praseodymium and samarium in amounts of 0.0043 to 0.043 mg/ml, at Nd$\Delta$Pr(Sm) ratios from 1:99 to 1:8. (TTT)

**32** COLORIMETRIC DETERMINATION OF URANIUM WITH THE AID OF 6(2-THIAZOLYLAZO)-3-DIMETHYLAMINOPHENOL (TAM). Kasiura, Krzysztof; Minczewski, Jerzy (Warsaw Technical Univ.). Nukleonika, 11: 399-405(1966).

A method for determination of uranium was devised. The pH range within which the color complex is formed was determined, a suitable extractant was chosen, and the effect of diverse ions was examined. The determination of uranium in samples was preceded by extraction with 20% tributyl phosphate in $CHCl_3$ from 7N $HNO_3$. The color reaction was developed by shaking extracts with an aqueous solution of TAM at pH 7. The effect of diverse ions was eliminated by using ethylenedinitrilotetraacetic acid (EDTA) as masking agent. The excess of EDTA was combined with the aid of calcium ions. (auth)

**33** EFFICIENCY OF SCINTILLATION COUNTING OF TRITIUM-LABELED DNA-PROTEIN IN THE MIXED LEUCOCYTE REACTION IN VITRO. Moorhead, John F.; McFarland, William (Veterans Administration Hospital, Washington, D. C. Georgetown Univ., Washington, D. C.). Nature, 211: 1157-9(Sept. 10, 1966).

Investigations were carried out to explain the variations in efficiency of scintillation counting observed with different methods of preparation. Results indicated that tritium-labeled DNA protein samples could be counted at room temperature with greater efficiency if acidified. Addition of water to the scintillator system stabilized it and enhanced counting efficiency, especially in the low energy part of the tritium spectrum. Small amounts of DNA (<3 mg) labeled with tritiated thymine were counted within a predictable narrow range of efficiency despite wide variations in sample activity. (P.C.S.)

**34** THE CORRECTION FOR FOIL ABSORPTION IN 4$\pi$-COUNTING OF SOURCES DEPOSITED ON THIN FOILS. van der Eijk, W. (EURATOM, Geel, Belg.). Int. J. Appl. Radiat. Isotop., 17: 604-6(Oct. 1966).

Sandwich backing techniques, where supplementary foils are applied symmetrically on both sides of the source, for corrections for foil absorption in 4$\pi$-counting of sources are described. From plots of the ratio of count rates at foil thickness d to count rates at d = 0 vs d, a mass absorption coefficient for $\beta$ particles was derived. Linear extrapolation of the experimental count rates to foil thickness zero gave the same results as those obtained when the open sources were measured before sandwiching. (M.C.G.)

**35** SPECTROPHOTOMETRIC STUDY OF THE REACTION BETWEEN URANIUM(VI) AND 8-HYDROXY-7-IODOQUINOLINE-5-SULFONIC ACID: DETERMINATION OF URANIUM. Isvoranu-Panait, C.; Negoiu, M.; Marica, M. (Univ. of Bucharest). An. Univ. Bucuresti, Ser. Stiint. Nat., 12: 22-37(1963). (In Rumanian).

Two methods are described for developing the complex between uranium(VI) and 8-hydroxy-7-iodoquinoline-5-sulfonic acid for the spectrophotometric determination of uranium. Ten milliliters of an 0.56% solution of the reagent are added to the sample solution that is $\simeq$ 0.01 mM in U(VI) to give a pH of 2.4 to 2.6. Alternatively, the pH of the sample may be adjusted to 5.5 to 6 before the reagent is added. Using the first method of complex formation, the molar ratio of U to reagent is 1:1; by the second, it is 1:2. Beer's law is obeyed for the first method over the concentration range of 11.9 to 95$\mu$g of U/ml, and for the second with 9.5 to 95$\mu$g/ml. (Anal. Abstr.)

**36** COLORIMETRIC DETERMINATION OF CERIUM(III) WITH HAEMATOXYLIN. Popa, G.; Croitoru, V.; Chirica, G.; Draghia, V. (Univ. of Bucharest). An. Univ. Bucuresti, Ser. Stiint. Nat., 12: 19-22(1963). (In Rumanian).

In a method for the colorimetric determination of Ce(III) with hematoxylin, the color is developed by adding 1 drop of aqueous ammonia (to produce a pH of 7.2 to 7.5) and 2 ml of a 1% hematoxylin solution in 1% aqueous $NaC_2H_3O_2$ to a slightly acid sample solution containing 0.02 to 1 mg of Ce and diluting to a volume of 25 ml with water. The extinction is measured at 428m$\mu$ against a reagent blank. Beer's law is obeyed over the range of 0.9 to 36.3$\mu$g of Ce/ml. The complex contains 2 moles of hematoxylin per mole of Ce. (Anal. Abstr.)

**37** NUCLEAR RESONANCE SPECTROSCOPY AS A CHEMICAL INVESTIGATION METHOD. Suhr, Harald (Univ., Tuebingen, Ger.). Naturwissenschaften, 53: 417-22(Sept. 1966). (In German).

The principles of nuclear resonance spectroscopic methods are briefly outlined and the chemical displacements occurring are illustrated. The effects of spin-spin coupling are outlined. The use of nuclear resonance for structure clarification, analysis of mixtures, kinetic measurements, studies of H bonds, and analysis of solids is summarized. (J.S.R.)

**38** TOROIDAL ANALYZER (Engineering Materials). (Dow Chemical Co., Pittsburg, Calif. Western Div.). (CAPE–1485).

3 drawings.

An improved transistorized toroidal conductivity analyzer is used to determine acid content of plutonium bearing solutions. The analyzer consists of two driving toroids wired in parallel with a sensing toroid in the center. The driving toroids are connected to a phase shift oscillator and the sensing toroid is connected to a 2-transistor amplifier and readout meter. A thermistor is employed as the sensor. (For details see TID-4100 Suppl 37) (F.S.)

**39** DENSITY ANALYSIS DRY BOX (Engineering Materials). (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). (CAPE–1482).

One drawing.

The dry box is used in the falling-drop density analysis of isotopic hydrogen purity in lithium deuteride. The Al dry box is 2½ ft high and 20 in. deep and has a 12 in. square air lock and 2 main compartments, each 2½ ft long, which have top and front windows for illumination and observation. In the wall of the air lock is a 2½ in. diameter brass pipe with end caps to facilitate movement of samples and small pieces of equipment. The main compartments, air lock, pass tube, and reaction chamber are supplied with dry argon, and trays of $P_2O_5$ are maintained in the box. (For details see TID-4100 Suppl. 37) (F.S.)

**40** A 12 INCH, 90 DEGREE SECTOR SINGLE FOCUSING MASS SPECTROMETER FOR THE ANALYSIS OF CORROSIVE GASES. Stover, R. N.; Kerfoot, E. G.; Michlik, M. M. (Nuclide Corp., State College, Pa.). 4p. (CONF-651004–17). ORAU.

From 9th Conference on Analytical Chemistry in Nuclear Technology, Gatlinburg, Tenn.

Design modification of the mass spectrometer for analysis of $UF_6$ and other corrosive gases is announced. The instrument uses an electron-bombardment ion source and

ratio detection system with a 90° single-focusing mass spectrometer. The 12-in. radius analyzer provides more than adequate resolution and abundance sensitivity for analyses of minor isotopes. Differential pumping practically eliminates flow of $UF_6$ gas into analyzer region. Stability of electronic circuits allows repeated analyses without peak rescanning devices. Precision of measurement of $^{235}U : ^{238}U$ is ±0.02%. (P.C.S.)

**41** DETERMINATION OF SELENIUM IN AMINO ACIDS AT THE 0.1 ppm-LEVEL BY PULSED NEUTRON ACTIVATION. Maxia, Vera; Rollier, M. A. (Univ. of Pavia, Italy). 10p. (CONF-660606-27). ORAU. Gmelin, AED-CONF-66-203-81.

From American Nuclear Society Meeting, Denver, Colo.

The results of experiments to determine traces of Se in simulated biological samples, particularly amino acids, by pulsed neutron activation analysis are reported. The samples were synthesized by adding known amounts of $Na_2SeO_3$ to aqueous solutions containing glycine. Neutron irradiation conditions and counting procedures are described in detail. The starting time for counting was delayed 25 sec after pulsing to sufficiently lower the background due to interfering gamma-emitting activities without causing too large a loss of Se activity. Thirty second counting periods were used, and measurements were made evaluating the photopeak area of the 0.160-MeV $^{77m}Se$ $\gamma$ ray. The results are presented in tabular form and indicate a good proportionality between the measured activity and the level of Se in the concentration range of 0.36 to 0.09 ppM. The average level of activity per microgram of Se was $2.73 \times 10^4$ with a standard deviation of ±1.3%. (B.L.M.)

**42** DETERMINATION OF TRACE ELEMENTS IN MILK AND MILK PRODUCTS BY MEANS OF NEUTRON ACTIVATION ANALYSIS. Samuelsson, E.-G. (Dairy Dept., Alnarp, Sweden). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-75/20, 20p. (CONF-660711-4). ORAU.

From Seminar on the Use of Radioisotopes and Radiation in Dairy Science and Technology, Vienna.

The steps included in analysis by neutron activation are described. Advantages of activation analysis are that it is extremely sensitive as compared with other methods of analysis and that it avoids risk for interference from other metals. A formula is given for the radioactivity formed by the neutron irradiation. The formula shows that the activity will increase with the neutron flux. Besides the neutron flux, the irradiation time, the isotopic abundance of the particular nuclide involved in the reaction requested, and the mean activation cross section of the target nucleus are significant for the sensitivity of the method. Gamma ray spectrometry is used for measuring many of the radionuclides produced during irradiation. Determination of half-lives must be made in connection with spectrometry where determinations of a nuclide are concerned. The inorganic salts in milk and dairy products consist mainly of calcium, sodium, potassium, phosphorus and magnesium. Phosphorus, potassium and sodium are responsible for more than 99% of the radioactivity induced during the neutron irradiation. This will conceal the radiation from elements with low concentration, e.g., copper, and the effect of sodium, potassium and phosphorus must therefore be eliminated in some way before the trace elements can be determined. A detailed procedure for determining copper in milk is described. Contamination from metal particles from sampling equipment may be a source of error. (H.L.W.)

## Inorganic, Organic, and Physical Chemistry

*Refer also to abstracts 132 and 303.*

**43** (AD-630904) INVESTIGATION OF CHARGE NEUTRALIZATION PHENOMENA BETWEEN POSITIVE AND NEGATIVE IONS. Final Report, May 20, 1963–December 30, 1965. Haaland, Carsten M. (IIT Research Inst., Chicago, Ill.). Contract AF 19(628)-3252. 46p. (AFCRL-66-159). CFSTI $2.00 cy, $0.50 mn.

A technique for measuring positive ion–negative ion two-body reaction rates was developed for measuring the reaction rates of NO (+) with $O_2$ (–). Thermal ions were produced by photoionization of NO and photoelectrons produced in a separate chamber containing oxygen were allowed to attach to the neutral gas to produce $O_2$ (–). The two species were allowed to react by removal of a gas-actuated shutter dividing the two chambers. The reactant period was measured by actuation of a second shutter separating the reaction chamber from a time-of-flight mass spectrometer. The time-of-flight mass spectrometer was modified to provide a 100 kc/sec sample rate, a theta pinch lyman-alpha light source was developed, and the shutter speeds of 10,000 cm/sec were attained. (auth)

**44** (AD-630997) POTENTIAL ENERGY CURVES FOR $N_2$, NO, $O_2$, AND CORRESPONDING IONS. Gilmore, F. R. (RAND Corp., Santa Monica, Calif.). Apr. 1966. Contract AF 49(638)-1700. 50p. (RM-4034-1-PR). CFSTI $3.00 cy, $0.50 mn.

Potential energy curves for the observed electronic states $N_2$, $N_2$ (+), NO, NO (+), $O_2$, and $O_2$ (+) were calculated from published spectroscopic data by a numerical modification of the Rydberg-Klein method. Potential energy curves for a number of predicted but unobserved states of these molecules, and of the ground states of $N_2$ (–) (unstable), NO (–) and $O_2$ (–), were estimated with the help of simple theoretical considerations, published quantum-mechanical calculations, and indirect experimental evidence. The results are presented graphically. (auth)

**45** (CEA-R-3023) REDUCTION ELECTROLYTIQUE DU PENTAVALENT PROTACTINIUM. (The Electroreduction of Protactinium Pentavalent). Musikas, Claud (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). May 1966. 31p. Dep. mn.

The reduction of pentavalent protactinium to tetravalent protactinium, in sulfuric and hydrochloric media, on a milligram scale was demonstrated by electrolysis in a separate-compartment cell. There was no indication that protactinium may exist at the trivalent state in these solutions. Polarograms in fluoride solutions showed only one reduction wave. The principle of a volumetric method for the titration of protactinium is given. (auth)

**46** (GA-5611) THE HIGH-TEMPERATURE CHEMISTRY OF FISSION-PRODUCT ELEMENTS. Summary Report, August 1, 1963–July 31, 1964. Bell, W. E.; Norman, J. H. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Aug. 31, 1964. Contract AT(04-3)-164. 15p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Results are reported for studies on: mass spectrometry of gaseous oxides of rhodium; vapor pressure of palladium; partial pressure of palladium oxide; oxychlorides of iridium; thermodynamics of dimerization and trimerization of gaseous tungsten trioxide and molybdenum trioxide; mass spectrometry of gaseous oxides of iridium; dissociation of solid iridium oxide; dissociation of palladium oxide; stability of gaseous alkali metal oxides; and crystallography of metal trichlorides. Brief summaries are also reported for investigations completed in previous years and investigations in progress. (P.C.H.)

**47** (JINR-P-2895) ASTAT (OBZOR). (Astatine). Nefedov, V. D.; Norseev, Yu. V.; Toropova, M. A.; Khalkin, V. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 35p. Dep. mn.

A review is presented on the preparation and properties of astatine. Data on new inorganic and organic astatine forms are included. (113 references). (P.C.H.)

**48** (MCW-1500) LABORATORY DEVELOPMENT OF THE URANIUM ELECTROREDUCTION PROCESS. Pi-

per, R. D. (Mallinckrodt Chemical Works, Weldon Spring, Mo. Uranium Div.). July 1, 1966. Contract 14-108-eng-8. 38p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

A laboratory process for electroreduction of uranium oxides to uranium metal was carried out in a molten fluoride-salt electrolyte at temperatures above 1130°C. An all-liquid approach gave up to 44% current efficiency and very flexible operation, and a frozen-crust approach gave 80% current efficiency but was more limited in operation. (auth)

**49** (ORNL-TM-1592) SOL-GEL PREPARATION OF LANTHANIDE OXIDE MICROSPHERES AND CHARACTERIZATION OF SOLS AND GELS OF LANTHANIDE HYDROXIDES, THORIA, URANIA, AND PLUTONIA. Hardy, C. J. (Oak Ridge National Lab., Tenn.). Aug. 12, 1966. Contract W-7405-eng-26. 33p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Laboratory methods have been developed to produce microspheres of lanthanide oxides with a controlled size (50- to 500-$\mu$ dia), high density (up to 98% of theoretical crystal density), low surface area (0.01–0.1 $m^2/g$), and good crushing strength, by using sols and gels of the hydroxides as intermediates. UV, visible, ir, and Raman spectra of sols and gels of lanthanide hydroxides, thoria, urania, and thoria–$UO_3$ mixtures, were measured to: determine the nature of the bonding between the components, e.g., nitrate and lanthanide ions; obtain rapid analyses for nitrate and lanthanide ions; and determine the size of the colloidal particles by turbidity and light-scattering measurements (both methods gave results in good agreement for thoria sols containing particles of 200 A diameter, but appreciably larger than the crystallite size measured by x-ray linebroadening; the difference may be due to aggregation or to poly-dispersity). Preliminary measurements of the turbidities of plutonia sols were made, and difficulties were experienced in interpreting the results; the particles in one sol appeared to have a diameter of about 640 A and a molecular weight of $9 \times 10^8$. Sols and gels of lanthanide hydroxides and urania were examined by electron microscopy and electron diffraction to determine the size, shape, and crystallinity of the colloidal particles at the various stages in the processes to make microspheres of oxides. (P.C.H.)

**50** CRYSTALLINE STRUCTURE OF $Th(HCOO)_4 \cdot 3H_2O$. Arutyunyan, E. G.; Antsyshkina, A. S.; Balta, E. Ya. Zh. Strukt. Khim., 7: 471-2(May-June 1966). (In Russian).

Crystals of thorium formate trihydrate, synthesized in the laboratory, were narrow, monoclinic, colorless prisms. The structure of $Th(HCOO)_4 \cdot 3H_2O$ is considered to be a three-dimensional frame of thorium atoms connected by formate bridges. Each thorium atom is surrounded by eight oxygen atoms of the eight formate groups. Six of these eight atoms form a triangular prism, and the other two are centered on its square face. The average thorium distance is 2.48 Å, and in the thorium coordination sphere there are two or three molecules of water at a distance of 3.1 Å. Thorium coordinates were determined to be x = 0.390, y = 0.250, and z = 0.204. Each thorium atom is surrounded by eight other thorium atoms at a distance of 6.5 to 7.1 Å. (TTT)

**51** ELECTRON PARAMAGNETIC RESONANCE IN $UF_4$ AND $UF_3$. Shcherbakova, M. Ya.; Gabuda, S. P.; Gagarinskii, Yu. V. (Inst. of Geology and Geophysics, Academy of Sciences, Novosibirsk, Siberian SSR. Inst. of Inorganic Chemistry, Novosibirsk, USSR. Inst. of Physics, Krasnoyarsk, USSR). Zh. Strukt. Khim., 7: 449-50(May-June 1966). (In Russian).

The EPR of $UF_4$ and $UF_3$ was studied, using concentrates and solid solutions in $ThF_4$ and $ZrF_4$ (i.e., $U_nTh_{1-n}F_4$ and $U_nZr_{1-n}F_4$ where n = 0.2, 0.05, and 0.005), in order to obtain information on the unpaired electrons. The concentrates, which contained hundredths of a percent iron and nickel as impurities, gave weak spectrums. The solid solutions, which contained 10-fold less iron and 60-fold less nickel, gave no spectrum, even with the most sensitive spectrometer. Therefore the electron paramagnetic resonance of less pure samples is considered to be determined by the iron and nickel present. The results agree with the suggestion that in $UF_4$ and $UF_3$ the unpaired electrons are in the f position, well screened from the crystal region, as is also the case of the rare earth compounds. (TTT)

**52** PREPARATION AND THERMAL BEHAVIOR OF BINARY URANYL CARBONATES. Jindra, J.; Skramovsky, S. (Charles Univ., Prague). Collect. Czech. Chem. Commun., 31: 2639-45(July 1966). (In German).

By means of gravimetric and differential thermal analyses, the binary uranyl carbonates with ammonium, alkaline earth metals, and divalent cations of heavy metals (Cu, Ni, and Co) were investigated. The Cu, Ni, and Co compounds were prepared for the first time. (tr-auth)

**53** RARE EARTH–HYDROGEN SYSTEMS. II. DISPERSIONS IN MERCURY. Warf, James C.; Korst, William L.; Hardcastle, Kenneth I. (Univ. of Southern California, Los Angeles). Inorg. Chem., 5: 1726-8(Oct. 1966).

Solid hydrides of metals behave differently toward mercury, this behavior depending to some extent on the bonding type. Pulverized lanthanum and cerium hydrides were found to be wet by mercury, forming dispersions with a strong tendency to adhere to glass. Cerium hydride dispersions decomposed into hydrogen and cerium amalgams above approximately 115° and reacted vigorously with water at room temperature. On exposure to air, dilute dispersions oxidized to cerium(IV) oxide, while the more concentrated preparations oxidized, in part, and precipitated the unchanged hydride, in part. Lanthanum and ytterbium hydride dispersions in mercury yielded x-ray diffraction patterns different from those of the pure hydrides, showing surface formation of new compounds. Uranium hydride in mercury gave the normal diffraction pattern of $UH_3$. Freezing and melting curves of uranium hydride and cerium hydride dispersions showed no depression of the freezing point of the mercury. Filtration of cerium hydride dispersions through sintered glass removed nearly all of the dispersed phase and gave a filtrate 0.008% in cerium hydride. (auth)

**54** SPECTROPHOTOMETRIC STUDIES OF FORMATION OF COMPLEXING URANYL WITH RESORCIN IN AQUEOUS SOLUTIONS. Galinker, E. V.; Shnaiderman, S. Ya.; Opeida, N. N. Zh. Obshch. Khim., 36: 1540-4 (Sept. 1966). (In Russian).

Spectrophotometric studies of the complex formed by uranyl ions with resorcinol in aqueous solutions showed that at pH 3.0 to 4.5 the reaction may be described by the equation $UO_2^{2+} + H_2R \rightleftharpoons UO_2HR^+ + H^+$. The magnitudes of the apparent light absorption molar coefficient were found and formal equilibrium and instability constants were calculated for the simple complex $UO_2HR^+$ showing $K_{equil.} = 0.4 \times 10^{-3}$ and $K_{inst.} = 1 \times 10^{-6}$. Postulations are offered about the subsequent complexing stages. (R.V.J.)

**55** AMERICIUM(III) PERXENATE. Marcus, Y.; Cohen, Donald (Argonne National Lab., Ill.). Inorg. Chem., 5: 1740-3(Oct. 1966).

Americium perxenate was prepared by precipitation from basic solutions of americium(III). The compound is orange and shows the characteristic absorption bands of Am(III) in the visible and near-infrared regions, as well as the characteristic infrared absorption at 650–680 $cm^{-1}$ for the Xe–O vibration in perxenate. The compound is highly hydrated and has the stoichiometric composition $Am_4(XeO_6)_3 \cdot 4OH_2O$. Its solubility in water is $4.6 \times 10^{-5}$ Mole. The compound dissolves in acid to form Am(VI) and Am(V). (auth)

**56** OXYGEN ISOTOPIC EFFECT ON THE REDUCTION OF AQUO- AND HYDROXOPENTAAMMINECOBALT(III). Diebler, Hartmut; Dodel, Peter H.; Taube, Henry (Stanford Univ., Calif.). Inorg. Chem., 5: 1688-91(Oct. 1966).

The oxygen isotopic fractionation factor (d ln $^{16}O$/d ln $^{18}O$ = f) in the reduction of $(NH_3)_5CoOH_2^{3+}$ by the "outer-sphere" reagent $Ru(NH_3)_6^{2+}$ is observed to be 1.021 and in the reduction of $(NH_3)_5CoOH^{2+}$ is 1.017. The latter result differs quite markedly from that observed (f = 1.04) in the reaction of the hydroxy ion with $Cr^{2+}$, and it thus seems likely that the value of f may be useful in classifying the reaction mechanism. The reducing agents $V^{2+}$ and $Eu^{2+}$ and a number of metals acting as cathodes show values of f close to those observed for $Ru(NH_3)_6^{2+}$, indicating that the activation of the Co(III) complex demanded by them is similar. Several reducing agents complexed by EDTA give values of f close to unity, and it is suggested that in these cases inner-sphere mechanisms operate with substitution in the reducing agent being rate determining. (auth)

**57** RARE EARTH–HYDROGEN SYSTEMS. I. STRUCTURAL AND THERMODYNAMIC PROPERTIES. Korst, William L.; Warf, James C. (Univ. of Southern California, Los Angeles). Inorg. Chem., 5: 1719-26(Oct. 1966).

Crystallographic studies of hydrogen and deuterium systems with La, Ce, Pr, and Nd were carried out. Using a silica fiber torsion balance, dissociation pressure–composition relationships of the hydrides and deuterides of the rare earth elements were measured, and these were used to compute enthalpy, free energy, and entropy changes. Equations of the type log P = A – B/T predicted the plateau pressures satisfactorily (two solid phases), and equations of the type log P = Dn – E (n = hydrogen : metal ratio) roughly predicted dissociation pressures in the hydrogen-rich (one solid phase) regions. An approximately linear contraction of the fcc phase was observed as the dihydride is progressively converted to the trihydride. Statistical mechanical analysis permitted estimation of metal–hydrogen and hydrogen–hydrogen interaction energies within the solid phase and also provided a means of estimating the relative distribution of the hydrogen in tetrahedral and octahedral sites as a function of temperature. The hardness of ytterbium and its dihydride was measured. Evidence is presented that an actinium hydride reported in the literature is the dihydride. (auth)

**58** MECHANISM OF ETHER FORMATION FROM PHENOLS OVER $ThO_2$. Knoezinger, Helmut; Kudla, Lutz (Univ., Munich). Naturwissenschaften, 53: 431-2(Sept. 1966). (In German).

The reactions of phenol, m-cresol, p-cresol, p-$C_2H_5$-phenol, p-tert-$(CH_3)_3C$-phenol, p-Cl-phenol, p-$NO_2$-phenol, p-$CH_3O$-phenol, and p-$CF_3$-phenol and of ethanol with phenol-p cresol, and p-$C_2H_5$-phenol on $ThO_2$ were investigated between 300 and 600°C. The reaction products were analyzed by gas chromatography and infrared and NMR spectroscopy. The principal products of the reactions of phenols are in all cases symmetric aromatic ethers. In reactions of ethanol with phenol-cresol and p-ethylphenol mixed aliphatic-aromatic ether was found. (J.S.R.)

**59** INVESTIGATION OF COMPLEXING OF NEODYMIUM-5,7 DICHLOROXIN-AMYL ACETATE-WATER SYSTEM BY MEANS OF DISTRIBUTION METHOD. Romantseva, T. I.; Gromova, M. I.; Peshkova, V. M. Vestn. Moskov. Univ., Ser. II: Khim., No. 2, 80-2(Mar.–Apr. 1966). (In Russian).

An empirical formula for the distribution coefficient of neodymium (traced with $^{147}Nd$) in aqueous amyl acetate containing 5,7-dichloroxine ($1.25 \times 10^{-2}$ or $2.3 \times 10^{-3}$ M) was derived from experimental data. The composition of the neodymium complex was shown to be $MA_n$. Because polynuclear complexes were not formed at neodymium concentrations of $1 \times 10^{-4}$ g-ion/liter or lower, neodymium concentrations of $1.68 \times 10^{-5}$ g-ion/liter were used. Comparison of the data obtained earlier for the Nd-$Cl_2$OX-$CHCl_3$-$H_2O$ system with those obtained in these experiments indicated that the amyl acetate system has an advantage over chloroform for extraction of dichloroxinates of the rare earth elements. This may be due to the higher acidity at which amyl acetate extraction starts, where there is no hydrolysis of the rare earth ion, since neodymium hydrolyzes at pH's above 7. (TTT)

**60** EXCHANGE WITH DEUTERIUM OF POLYMETHYLCYCLOPENTANONES ON METALLIC FILMS. Cornet, Daniel; Gault, Francois G. (Univ., Paris, Caen, France). Bull. Soc. Chim. France, No. 8, 2477-80(Aug. 1966). (In French).

The exchange with deuterium of four cyclopentanones containing one, two, or four methyl substituents was studied on films of palladium and nickel. The hydrogens of the different molecules can be classified in the three following groups according to their reactivity: hydrogens in the alpha position; hydrogens in the beta position not separated from the carbonyl by a quaternary carbon; hydrogens in the ring separated from the carbonyl by a quaternary carbon; and hydrogens of the geminal dimethyl groups. (tr-auth)

**61** TELLURITES OF THE RARE EARTH ELEMENTS. Dobrowolski, Jan (Ecole Polytechnique, Danzig). Rocz. Chem., 40: 1169-72(1966). (In French).

The tellurites of nearly all rare earth elements except those of cerium(III) and promethium, which have not been described in the literature, were prepared and investigated (auth)

**62** THERMOGRAVIMETRIC AND X-RAY EXAMINATION OF GADOLINIUM PYROPHOSPHATES. Tananaev, I. V.; Kuznetsov, V. G.; Petushkova, S. M. (Kurnakov Inst. of General and Inorganic Chemistry, Academy of Sciences, USSR). Zh. Neorg. Khim., 11: 286-93(Feb. 1966). (In Russian).

Thermogravimetric and x-ray studies were made on the solid phases of separated $GdCl_3-M_4P_2O_7-H_2O$ (where M is Li, Na, K) and $GdCl_3-Cs_4P_2O_7-H_2O$ systems at 25°C. Thermogravimetric and x-ray data are given for $Gd_4(P_2O_7)_3 \cdot 13H_2O$, $KGdP_2O_7 \cdot 3H_2O$, $Gd_4(P_2O_7)_3 \cdot Gd(OH)_3 \cdot 9H_2O$, and $CsGdP_2O_7 \cdot 4.5H_2O$ and products of their thermal treatment. (tr-auth)

**63** NEODYMIUM AND SAMARIUM PERRHENATES. Plyushchev, V. E.; Varfolomeev, M. B. (Inst. of Fine Chemical Tech., Moscow). Zh. Neorg. Khim., 11: 294-8 (Feb. 1966). (In Russian).

The physicochemical properties of the crystal perrhenates $Me(ReO_4)_3 \cdot 4H_2O$ and $Me(ReO_4)_3 \cdot H_2O$ (Me is Nd or Sm) were studied and their thermal stability was determined. Anhydrous salts were obtained by thermal decomposition of neodymium and samarium perrhenate crystal hydrates and their physical and chemical properties studied. (tr-auth)

**64** THERMAL ANALYSIS OF SOME METAL BENZOHYDROXAMATES. Lapatnick, Leonard N.; Hazel, J. Frederic; McNabb, Wallace M. (Univ. of Pennsylvania, Philadelphia). Anal. Chim. Acta, 36: 366-71(Nov. 1966).

The preparation and thermal analysis of metal chelates of benzohydroxamic acid (BHA) with Al(III), Cd(II), Co(II), Cu(II) (two compounds), Fe(III), La(III), Pb(II), Mn(II), Ni(II), U(VI), and Zn(II) is discussed. The Al(III), La(III), Pb(II) and Mn(II) chelates are new compounds. DTA and TGA curves of the chelates and of BHA are presented, and the heats of decomposition of the chelates are estimated. (auth)

**65** PREPARATION AND PROPERTIES OF AMMONIUM URANYL TETRAHALIDES. Gueguin, Michel (Univ., Paris, Rennes, France). Compt. Rend., Ser. C, 263: 719-21(Sept. 12, 1966). (In French).

The anhydrous ammonium uranyl tetrahalides, $(NH_4)_2UO_2X_4$ (X = Cl or Br), are prepared, in general, starting with the oxide, $UO_3$, and the halides, $NH_4X$, with the intermediate formation of dihalogen uranates, $(NH_4)_2OU_3X_2$. The treatment of these salts, under oxygen or chlorine, leads, respectively, to the complexes $(NH_4)U_2O_6X$ and $(NH_4)(UO_2)_2Cl$; conversion to the corresponding potassium salts confirms these formulas. (tr-auth)

**66** THERMODYNAMIC INVESTIGATION OF EVAPORATION OF LOW NIOBIUM OXIDES. Shchukarev,

S. A.; Semenov, G. A.; Frantseva, K. E. (Leningrad State Univ.). Zh. Neorg. Khim., 11: 233-6(Feb. 1966). (In Russian).

Mass spectrometric studies were made on NbO and $NbO_2$ evaporation processes. The vapor pressure over niobium oxides, thermal sublimation, free energy of formation, and dissociation energy of gaseous niobium oxides were measured and analyzed. (tr-auth)

**67** INVESTIGATION OF URANIUM(IV) COMPLEXES IN ALUMINUM SALT SOLUTIONS. Vdovenko, V. M.; Romanov, G. A.; Shcherbakov, V. A. Zh. Neorg. Khim., 11: 252-5(Feb. 1966). (In Russian).

Spectrophotometric and proton resonance analyses were made of uranium(IV) fluoride complex behavior in aqueous solutions containing aluminum salts. An increased concentration of aluminum salts disintegrated the $UF^{3+}$ complex resulting in fluoride aluminum complexes. The stability constants of the complexes were $UF^{3+}$($K_{UF^{3+}} = 6 \times 10^8$) and $UF_2^{2+}$($K_{UF_2^{2+}} = 7 \times 10^5$ and $4 \times 10^5$). (tr-auth)

**68** GADOLINIUM CHLORIDE REACTIONS WITH PYROPHOSPHATE IONS. Tananaev, I. V.; Petushkova, S. M. Zh. Neorg. Khim., 11: 282-5(Feb. 1966). (In Russian).

Solubility, electric conductivity, and pH measurements were used in the analysis of $GdCl_3$ reactions with $Li_4P_2O_7$ and $Cs_4P_2O_7$ in aqueous solutions. The results showed that the reaction of $GdCl_3$ with $Li_4P_2O_7$ resulted in only one poorly soluble salt $Gd_4(P_2O_7)_3 \cdot 13H_2O$ whereas reactions with $Cs_4P_2O_7$ resulted in two compounds, $Gd_4(P_2O_7)_3 \cdot Gd(OH_3 \cdot 9H_2O$ and $CsGdP_2O_7 \cdot 4.5H_2O$. The preparation of $Gd_4(P_2O_7)_3 \cdot 13H_2O$ is described along with its properties. (R.V.J.)

**69** REACTIONS OF MELTED HOLMIUM AND ERBIUM CHLORIDES WITH POTASSIUM CHLORIDES. Korshunov, B. G.; Drobot, D. V.; Galchenko, I. E.; Shevtsova, E. N. (Inst. of Fine Chemical Tech., Moscow). Zh. Neorg. Khim., 11: 411-14(Feb. 1966). (In Russian).

Thermographic analyses were made of reactions in the $HoCl_3$–KCl and $ErCl_3$–KCl systems and melt diagrams of the systems were constructed. The density of the chemical compounds prepared was determined, and the composition of KCl-rich melts was found. X-ray analysis of the solid phases showed the isomorphous state of $K_3HoCl_6$, $K_3ErCl_6$, and $K_3YCl_6$. (tr-auth)

**70** ISOTOPE EFFECT STUDIES ON ELIMINATION REACTIONS. V. THE MECHANISM OF THE CARBONYL ELIMINATION REACTION OF 9-FLUORENYL NITRATE WITH ACETATE ION. Smith, P. J.; Bourns, A. N. (McMaster Univ., Hamilton, Ont.). Can. J. Chem., 44: 2553-61(Nov. 1966).

The carbonyl elimination reaction ($E_{CO}2$) of 9-fluorenyl nitrate with acetate ion in anhydrous ethanol was found to be second order and to give at 30°C primary nitrogen-15 and deuterium isotope effects of 1.0091 ± 0.0007 and 4.3 ± 0.2, respectively. The ester showed no deuterium exchange with solvent under the reaction conditions. A change in solvent to 85 vol % ethanol–water increased the nitrogen isotope effect to 1.0131 ± 0.0007 without changing the deuterium effect. These results exclude any form of two-stage carbanion intermediate mechanism, but are in accord with a concerted process. (auth)

**71** DEUTERIUM ISOTOPE EFFECT ON THE RACEMIZATION OF A HIGHLY HINDERED BIPHENYL DERIVATIVE. Heitner, C.; Leffek, K. T. Can. J. Chem., 44: 2567-70(Nov. 1966).

The rate of racemization of an optically active biphenyl derivative was measured and compared with that of the normal compound. Results showed that secondary deuterium isotope effects in biphenyl systems are more complicated than simply steric effects. Limitations of Mislow's conclusion, "that steric hydrogen isotope effects are plainly operative only under special conditions of severe overcrowding" are discussed. (F.S.A.)

**72** INDUCED INFRARED ABSORPTION OF DEUTERIUM IN DEUTERIUM-FOREIGN GAS MIXTURES. Pai, S. T.; Reddy, S. Paddi; Cho, C. W. (Memorial Univ. of Newfoundland, St. John's). Can. J. Phys., 44: 2893-2903(Nov. 1966).

The pressure-induced fundamental infrared absorption band of deuterium was studied in deuterium–helium, deuterium–argon, and deuterium–nitrogen mixtures at pressures up to 1,200 atm at room temperature. The enhancement absorption profile of each mixture showed a well-resolved splitting of the Q branch into two components $Q_P$ and $Q_R$. While the enhancement contours of deuterium–helium mixtures did not exhibit any absorption peaks corresponding to the O and S branches, those of the other two binary mixtures showed a pronounced S(2) peak and an indication of several other O and S peaks of the band. Integrated absorption coefficients of the band were measured for all the mixtures, and the binary and ternary absorption coefficients were determined. The theory of Van Kranendonk and the available molecular parameters of deuterium and the perturbing gases were used to calculate the binary absorption coefficients of the individual lines of the O and S branches and of the quadrupole part of the Q branch of the band in all three binary mixtures. Using these calculated values and the experimental values of the total binary absorption coefficients of these mixtures, the overlap parts of the binary absorption coefficients of the Q branch were estimated. (auth)

**73** STUDIES OF THE RATE OF ACID CATALYZED OXYGEN EXCHANGE BETWEEN KETONES AND $^{18}O$-ENRICHED WATER IN ACETONITRILE BY INFRARED ABSORPTION ANALYSIS. Aksnes, Gunnar; Aksnes, Dagfinn; Albriktsen, Per (Univ., Bergen). Acta Chem. Scand., 20: 1325-9(1966).

Kinetic studies of the acid-catalyzed oxygen exchange between $^{18}O$-enriched water and acetone, acetophenone, and benzophenone in acetonitrile were performed. The reaction was followed by measuring the optical density of the $C=^{18}O$ stretching band in infrared. It was concluded that protonation of the ketones cannot be the rate-determining step of the exchange process. (auth)

**74** MIXED SOLVENT DEUTERIUM ISOTOPE EFFECTS ON THE DISSOCIATION OF PERIODIC ACID. Salomaa, Pentti; Vesala, Antti (Univ. of Turku, Finland). Acta Chem. Scand., 20: 1414-49(1966).

Transfer effects during the first and second dissociations of periodic acid in $H_2O$–$D_2O$ mixtures were studied by spectrophotometry. Evidence was found to support the published theory that the divalent anion is substantially in the hydrated form $IO_3(OH)_3^{2-}$. Reaction equations are presented and deviations between observed and calculated effects are discussed. (P.C.S.)

**75** BEHAVIOR OF $ThCl_4$ AND FORMATION OF THIOCYANATE COMPLEXES OF THORIUM IN NONAQUEOUS SOLUTIONS. Golub, A. M.; Kalibabchuk, V. A. (Kiev State Univ.). Zh. Neorg. Khim., 11: 590-9(Mar. 1966). (In Russian).

The properties of $ThCl_4$ and its interaction with KCNS were studied in acetone, methanol, and dimethylformamide (which have similar dielectric constants). It was shown conductometrically and pH-potentiometrically that $ThCl_4$ undergoes solvolysis in methanol, forming $ThCl_2(OCH_3)_2$, if its concentration is within the range of $1.95 \times 10^{-2}$–$1.52 \times 10^{-4}$ mole/l. The solvolysis constants were calculated. Conductometric and spectrophotometric studies of the interaction of $ThCl_4$ and KCNS showed the existence of thiocyanate complexes of thorium containing from 1 to 6 thiocyanate ligands. Thorium complexes richest in thiocyanate ligands were found in dimethylformamide. The calculated equilibrium constants for the reaction of complex formation indicate an increase in the stability of the complexes in the series dimethylformamide–methanol–acetone. IR spectroscopy established that the coordination of thiocyanate groups around thorium is accomplished via nitrogen atoms (isothiocyanate structure) and that the

bonding between dimethylformamide and the thorium atom is accomplished via oxygen atoms. In the reaction of complex formation in nonaqueous solutions, the composition and stability of the complex depend strongly on the chemical nature of the solvent. (ATD)

**76** THE NUCLEAR MAGNETIC RESONANCES AND MICROWAVE SPECTRA OF SOME DEUTERIO DERIVATIVES OF 2,4-DICARBACLOVOHEPTABORANE(7). Onak, Thomas; Dunks, Gary B.; Beaudet, Robert A.; Poynter, Robert L. (California State Coll., Los Angeles. Univ. of Southern California, Los Angeles. Jet Propulsion Lab., Pasadena). Contract NAS7-100. J. Amer. Chem. Soc., 88: 4622-5(Oct. 20, 1966).

In spite of the known structure of 2,4-dicarbaclovoheptaborane(7), ambiguous NMR assignments were obtained for both the $^{11}B$ and $^{1}H$ NMR spectra of this molecule. Deuterium exchange was expected to aid in the NMR analysis of this molecule. Although deuterium changes completely at high temperatures (400°C), at lower temperatures (100°C) deuterium exchanges in only three definite positions. A determination of these deuterium atom locations by microwave spectroscopy for the partially deuterated isotopic species allows an unequivocal assignment to be made for both the $^{11}B$ and the $^{1}H$ NMR spectra. For the partially deuterated molecule, the three deuterium atoms are preferentially substituted on the boron atoms in the base plane. These results are compatible with the NMR spectra for related boron compounds. (auth)

**77** STRUCTURAL EFFECTS ON CONCURRENT FIRST- AND SECOND-ORDER PROCESSES IN BORDERLINE NUCLEOPHILIC SUBSTITUTION. THE ISOTOPIC EXCHANGE BETWEEN SUBSTITUTED BENZHYDRYL THIOCYANATES AND IONIC THIOCYANATE IN ACETONITRILE AND ACETONE. Ceccon, Alberto; Papa, Ida; Fava, Antonino (Univ., Padua. Univ., Pisa, Italy). J. Amer. Chem. Soc., 88: 4643-8(Oct. 20, 1966).

A kinetic study was carried out of a typical borderline nucleophilic substitution, the isotopic exchange between substituted benzhydryl thiocyanate and ionic thiocyanate, for which, under certain specified conditions, the rate law is: rate = $k_1[R-SCN] + k_2[R-SCN][NaSCN]$. The structural effect was separately determined for the first- and the second-order rate contributions in a wide range of electron-attracting power of the substituents in the phenyl rings (from 4,4′-dimethyl to 4,4′-dinitro). The first-order rate coefficient, $k_1$, was excellently correlated by a linear-free-energy relationship ($\sigma^+$) characterized by a high negative value of $\rho(-4.5)$. The second-order rate coefficient showed extremely poor correlation and gave rise in the Hammett plot to a shallow U-shaped curve. From the magnitude of the structural effect, the first-order path was argued to involve an electron-deficient species past the intimate ion-pair stage, and the free carbonium ion suggested as the more likely intermediate. As to the second-order path, it was suggested to be a one-step displacement on the substrate, rather than a two-step process involving a carbonium–leaving group ion pair in fast equilibrium with the substrate. The arguments used to rule out the latter mechanism were based, besides the structural effect, on the estimation of the ionization rate. Other facets of direct nucleophilic substitution reactions discussed include the solvent effect and its change with structure, and the role that ion pairs of the nucleophile may play in determining the over-all second-order rate for different substrates. (auth)

**78** OPTICALLY ACTIVE trans-CYCLOOCTENE FROM AN ASYMMETRIC HOFMANN ELIMINATION. RESOLUTION AND HOFMANN DEGRADATION OF N-n-BUTYL-N-ISOBUTYL-N-METHYLCYCLOOCTYLAMMONIUM HYDROXIDE. Cope, Arthur C.; Funke, Wolfgang R.; Jones, Frank N. (Massachusetts Inst. of Tech., Cambridge). J. Amer. Chem. Soc., 88: 4693-9(Oct. 20, 1966).

Optically active trans-cyclooctene, $[\alpha]^{25}D -6.28°$, was obtained in 1.4% optical yield from Hofmann degradation of (–)-N-n-butyl-N-isobutyl-N-methylcyclooctylammonium hydroxide, which was prepared by fractional crystallization of the corresponding (+)-10-camphorsulfonate. When (–)-N-n-butyl-N-isobutyl-N-methylcyclooctylammonium perchlorate was treated with potassium amide in liquid ammonia, (+)-trans-cyclooctene, $[\alpha]^{25}D + 10.87°$, was obtained in 2.4% optical yield. The optical purity of the resolved quaternary ammonium cation used in both of these decompositions was determined by the isotopic dilution method using $^{15}N$ as the isotopic label. Isolation of the racemic $^{15}N$-enriched quaternary ammonium cation as its tetraphenylboron salt and determination of the isotopic dilution by mass spectrometry showed that the optical purity of the resolved material was 99.6% and that the degree of asymmetric induction obtained represented maximum values. (auth)

**79** HYDROGEN–DEUTERIUM EXCHANGE IN SOME HALOPYRIDINES AND THE MECHANISM OF PYRIDYNE FORMATION. Zoltewicz, John A.; Smith, Craig L. (Univ. of Florida, Gainesville). J. Amer. Chem. Soc., 88: 4766-7(Oct. 20, 1966).

An investigation of the rate of hydrogen exchange in 3-chloropyridine and 3,5-dichloropyridine was made using two different solvent systems, methanol and ammonia. Both incorporation of deuterium from $CH_3OD$ into unlabeled chloropyridine and removal of deuterium from substrate into $CH_3OH$ were examined. The rate of hydrogen exchange at the number 2 position of 3-chloropyridine was found immeasurably slow relative to the exchange rate at the 4 position. The extent of 3,4-pyridyne formation from the dehydrohalogenation of 3-chloropyridine was largely determined by solvent acidity. The absence of 2,3-pyridyne formation from 3-chloropyridine is discussed. (D.H.M.)

**80** DIRECT DETERMINATION OF THE EFFECT OF ISOTOPIC SUBSTITUTION ON BOND LENGTHS IN SOLID OXALIC ACID DIHYDRATE. Delaplane, Robert G.; Ibers, James A. (Northwestern Univ., Evanston, Ill.). J. Chem. Phys., 45: 3451-2(Nov. 1, 1966).

Normal and deuterated oxalic acid dihydrates were studied by x-ray-diffraction methods. The substance crystallizes with two molecules in Space Group $P2_1/N$ of the monoclinic system. There are 3 crystallographically independent O–H–O (or O–D–O) bonds in the structure. The C–C and C–O bond lengths were not changed by isotope substitution. The greatest change on deuteration occurred in the longest hydrogen bond. There was no correlation of bond-length changes with lattice-constant changes. (M.C.G.)

**81** VAPOR PRESSURE AND COMPOSITION IN THE KCl–$ThCl_4$ SYSTEM. Su, Mien-tseng; Novikov, G. I. Zh. Neorg. Khim., 11: 498-503(Mar. 1966). (In Russian).

An attempt was made to study compounds of MI–Cl–$ThCl_4$ type systems in vapor form. Total vapor pressure in the KCl–$ThCl_4$ system was measured by the boiling point method. The vapor pressure data obtained by analyzing the condensates over the melts can be explained only by assuming that a complex compound to which the composition $KThCl_5$ was ascribed by analogy with $NaZrF_5$ passes into the vapor state (the other substances present in the vapor are KCl, $K_2Cl_2$, and $ThCl_4$). On the basis of the experimental data, the equilibrium constants were calculated for the dissociation of the complex: $(KThCl_5) \rightarrow (KCl) + (ThCl_4)$, and the thermodynamic characteristics of equilibrium were computed: $H^0_{1280°K} = 49 \pm 3$ kcal/mole; $S^0_{1280°K} = 28 \pm 3$ e.u. Variation in stability in the series of vapor forms $K_2Cl_2$, $KSrCl_3$, $KLaCl_4$, and $KThCl_5$, i.e., in the sequence of the first four groups of the periodic system and also of the titanium subgroup, is discussed. (ATD)

**82** POTASSIUM NEPTUNYL TRICARBONATE. Gorbenko-Germanov, D. S.; Klimov, V. D. Zh. Neorg. Khim., 11: 516-19(Mar. 1966). (In Russian).

A new carbonate compound of neptunyl $NpO_2^{+}$ corresponding to the formula $K_4[NpO_2(CO_3)_3]$ was prepared. Its solubility in water and $K_2CO_3$ solutions at 20 ± 2°C was determined. Infrared spectra of the solid potassium neptunyl tricarbonate in the 3–15 μ range showed that it is iso-

structural with potassium uranyl tricarbonate. From the value of the $\nu_3$ band of $NpO_2^{2+}$ in $K_4[NpO_2(CO_3)_3]$, the force constant f of the Np–O bond in $NpO_2^{2+}$ was calculated (0.632 mdyne/cm), and the equilibrium length, r, of the Np–O bond was evaluated (1.75 Å). As in the uranyl compound, the symmetry of $CO_3^{2-}$ was found to decrease from $D_{3h}$ to $C_{2v}$ in the neptunyl compound. (ATD)

**83** POTASSIUM AND CESIUM NEPTUNOYL TRICARBONATES. Gorbenko-Germanov, D. S.; Zenkova, R. A. Zh. Neorg. Khim., 11: 520-8(Mar. 1966). (In Russian).

Potassium and cesium neptunoyl tricarbonates were prepared from neptunium dioxide, and analysis established their common formula as $R_5[NpO_2(CO_3)_3]$ ($R = K^+, Cs^+$). Their solubility in water, 0.2 M and 50% $K_2CO_3$ and $Cs_2CO_3$ solutions were determined. Data on the neptunium content of carbonate mother solutions indicate that the dicarbonate complexes $[NpO_2(CO_3)_2]^{3-}$ may be present. Absorption spectra of $NpO_2^+$ in 50% $K_2CO_3$ and $Cs_2CO_3$ solutions were recorded in the 9000–10500 Å range; a substantial decrease of the molar extinction coefficient, $\epsilon$, (by a factor of about 30) was observed as compared to the value of $\epsilon$ in 1 M $HNO_3$, indicating strong complex formation between $NpO_2^+$ and carbonate ions. A study of the absorption spectra of crystalline $R_5[NpO_2(CO_3)_3]$ ($R = K^+, Cs^+$) in the 9000–10000 Å range permitted the determination of molar extinction coefficients of the individual splitting components of the $NpO_2^+$ band in the 9500–9600 Å range. Analysis of vibrational ir spectra of the neptunoyl tricarbonates showed an increase in the interaction of $NpO_2^+$ with $CO_3^{2-}$ on passing from potassium to cesium, manifested in a decrease of the force constant, of the Np–O bond from 0.504 to 0.498 mdyne/cm ($r_{Np-O} = 1.80$ Å). The symmetry of $CO_3^{2-}$ in the neptunoyl tricarbonates was found to decrease from $D_{3h}$ to $C_{2v}$. (ATD)

**84** PROCESSES OF ISOTOPIC EXCHANGE ON PALLADIUM CATALYSTS. Schrage, Klaus; Burwell, Robert L. Jr. (Northwestern Univ., Evanston, Ill.). J. Amer. Chem. Soc., 88: 4549-55(Oct. 20, 1966).

There are at least five distinguishable processes in isotopic exchange between cyclopentane and deuterium on palladium-on-alumina catalysts at 40 to 70°C. One gives mainly cyclopentane-$d_{10}$, another gives mainly $d_9$, and a third gives mainly $d_5$. Two contribute to formation of $d_1$ to $d_3$. The activation energies for the various processes decrease from about 22 to 11 kcal/mole in the order in which the processes are listed. The kinetic orders in deuterium are about –1.2 for $d_9$ exchange, –0.85 for $d_{10}$, a little less negative for $d_5$, and only about –0.4 for $d_1$ to $d_3$. The isotopic exchange of methylcyclopentane and 1,1-dimethylcyclopentane can be similarly characterized. Owing to noncorrelated variation in the relative yields of the various cyclopentane-d's on different palladium catalysts, each of the five processes is assigned to a different set of surface sites. These results suggest that what appear to be single reactions may, in fact, be composite and more complicated in detail than commonly considered. (auth)

**85** MECHANISM OF THE ISOTOPIC EXCHANGE BETWEEN DEUTERIUM AND CYCLOALKANES ON PALLADIUM CATALYSTS. Schrage, Klaus; Burwell, Robert L. Jr. (Northwestern Univ., Evanston, Ill.). J. Amer. Chem. Soc., 88: 4555-60(Oct. 20, 1966).

In isotopic exchange between deuterium and bicyclo[3.3.1]nonane on palladium-on-alumina catalysts at about 60°C, the eight hydrogen atoms, which form the set that can be connected by cis-eclipsed conformations, largely exchange as a unit. In addition, $d_{10}$ and $d_{12}$ appear in the initial products in substantial amounts but $d_9$ and $d_{11}$ only in very small amounts. The large yield of $d_8$ supports the view that the fundamental exchange mechanism involves alternation between monoadsorbed and eclipsed diadsorbed alkane. The additional exchange of the second set of hydrogen atoms in cyclopentanes and cyclohexanes must involve separate sets of sites. Some form of the $\pi$-allyl mechanism is consistent with the results including formation of bicyclononane-$d_{10}$ and -$d_{12}$. Also consistent is some form of a roll-over mechanism in which an eclipsed diadsorbed species rolls over via a species containing five-coordinate carbon atoms which are bonded to two different surface sites. The last process can also provide a mechanism for formation of cyclopentane-$d_8$. Exchange of cyclohexane contrasts with that of cyclopentane: highly exchanged species are formed in much lower concentrations; increasing partial pressure of deuterium leads to marked reduction in the relative yield of extensively exchanged cyclohexane. This appears to result from the readier formation in cyclopentane vs. cyclohexane of an eclipsed diadsorbed species and of whatever intermediate is involved in exchanging both sets of hydrogen atoms in cyclopentane and cyclohexane. (auth)

**86** APPLICATION OF PARTIAL RESOLUTION IN HOMOGENEOUS PHASE. V. CONFIGURATION AND OPTICAL PURITY OF PRIMARY DEUTERATED ALCHOLS. Horeau, A.; Nouaille, A. (College de France, Paris). Tetrahedron Lett., No. 33, 3953-9(Aug. 1966). (In French).

The optical family of enantiomeric alcohols may be determined by reaction with racemic $\alpha$-phenylbutyric anhydride and examination of the activity of the excess $\alpha$-phenylbutyric acid at the end of the reaction. One may detect an optical yield of 0.015%, so that the rates of reaction of the isomers need differ by only a factor of 1.0003. Primary deuterated alcohols were found to give optical yields on the order of ½%, with rates differing by a factor of 1.01. A rule was established: "If in esterifying in dry pyridine a primary deuterated alcohol with an excess of racemic $\alpha$-phenylbutyric anhydride, one obtains (-)-$\alpha$-phenylbutyric acid, the alcohol has the R configuration, where H = M, D = S." The method is also used to determine the optical purity of partially resolved deuterated primary alcohols. Several examples of such determinations are given; these are in disaccord with previous estimates of purity in two cases, and in agreement in several others. The method may be applied to 100 mg of product. (BBB)

**87** PROPERTIES OF URANYL PHTHALOCYANINE. Berezin, B. D.; Zhukov, Yu. A.; Koifman, O. I. (Ivanovsk Chemical-Technological Inst., USSR). Dokl. Akad. Nauk SSSR, 167: 1318-20(Apr. 21, 1966). (In Russian).

An analysis was made of the physicochemical properties of the uranyl–phthalocyanine complex prepared from an anhydrous mixture of $UO_2(CH_3COO)_2$ and phthalonitrile heated for 4 hr in a round-bottom flask fitted with a reflux condenser and followed by further elution, filtration, and heating. The final product contained 27.1% U. Data on the kinetics of destruction of the uranyl–phthalocyanine complex in 14.0 to 17.6M $H_2SO_4$ at 25° are tabulated. Identical spectra and order of destruction of metal-free phthalocyanine and uranyl–phthalocyanine complex indicated that $UO_2Pc$ is labile phthalocyanine. Absorption spectra of the uranyl–phthalocyanine complex in dimethyl formamide, quinoline, $\alpha$-bromonaphthalene, and 17.6M $H_2SO_4$ are discussed. (R.V.J.)

**88** PROCESS FOR PREPARING STABILIZED ZIRCONIA SOLS. Fitch, Frederick T.; Smith, Jean G. (to W. R. Grace and Co.). U. S. Patent 3,259,585. July 5, 1966. Filed Aug. 14, 1963.

A process for preparing a zirconia sol made up of particles stabilized against the monoclinic-tetragonal phase transformation when the particles are heated to a temperature above 350°C consists of adding a compound of a metal selected from the group consisting of Sc, Y, and elements 62 to 71 of the periodic table in an amount sufficient to provide 1 to 50 mole % of the metal oxide in the sol, in an aqueous medium, to the zirconium salt solution. The mixed solution is then heated to 60 to 120°C for 30 min to 4 hr to complete the stabilized sol preparation. (B.L.M.)

**89** PREPARATION OF PLUTONIUM MONOSULFIDE AND PLUTONIUM MONOPHOSPHIDE. Kruger,

Owen L.; Moser, John B.; Wrona, Bernard J. (to U. S. Atomic Energy Commission). U. S. Patent 3,282,656. Nov. 1, 1966.

A process for the preparation of plutonium monosulfide and plutonium monophosphide is given. The plutonium metal reacted with hydrogen up to 200°C forming a plutonium hydride-containing product. The reaction product was cooled, pulverized, and heated to about 400°C, under reduced pressure, resulting in partial dehydridation. The partially dehydrided product reacted with hydrogen sulfide or phosphine and was subjected to two more dehydriding-reaction cycles, each subsequent cycle being carried out at a higher temperature than the preceding one. The product was vacuum heated between 1400 and 1600°C for homogenization. (AEC)

**90** METHOD FOR PREPARATION OF URANIA SOLS. Morse, L. E. (to U. S. Atomic Energy Commission). U. S. Patent 3,288,717. Nov. 29, 1966.

A method is described for preparing stable urania sols. A hydrous urania precipitate is prepared from an aqueous nitrate solution at a pH of 6.0 to 7.3 under a nonoxidizing atmosphere, filtered, and washed. The urania sol is then formed by heating the washed filter cake until it liquefies at a temperature between 60 and 80°C to peptize the urania. (AEC)

**91** PREPARATION OF PLUTONIUM HEXAFLUORIDE. Fischer, Jack (to U. S. Atomic Energy Commission). U. S. Patent 3,284,173. Nov. 8, 1966.

A process for removing a plutonium compound selected from the group consisting of plutonium dioxide, plutonium tetrafluoride, and plutonyl fluoride from alumina is described. The plutonium-containing alumina is mixed with a bismuth catalyst selected from the group consisting of bismuth metal and bismuth trifluoride. Fluorine gas is passed over the mixture after heating to between 450 and 600°C, whereby plutonium hexafluoride is formed and volatilized. (AEC)

## Radiation and Nuclear Chemistry

*Refer also to abstracts 133, 365, 501, and 822.*

**92** (AD-634693) OBSERVATION OF SHORT-LIVED SPECIES PRODUCED BY X-RAY PULSES. Klein, Nathan (Army Nuclear Defense Lab., Edgewood Arsenal, Md.). June 1966. 12p. CFSTI $1.00 cy, $0.50 mn.

Studies concerning the reactions of the hydrated electron during and immediately after an x-radiation pulse were made. (TAB)

**93** (AERE-R-5286) IRRADIATION OF CARBON DIOXIDE CONTAINING SMALL AMOUNTS OF HYDROGEN. FORMATION OF METHANE. Hummel, R. W. (Research Group, United Kingdom Atomic Energy Authority, Wantage (England)). Sept. 1966. 8p. Dep. mn. BIS $0.30. HMSO 1s. 9d.

Carbon dioxide containing up to 10 vol.% $H_2$ was irradiated in sealed silica bulbs at near-atmospheric pressures and between 200 and 400°C. Methane was not detected at the 0.02 and 0.2 vol.% $H_2$ levels. At the 2 and 10 vol.% levels the initial G values for $CH_4$ were 0.025 and 0.050, respectively, and were independent of temperature. (auth)

**94** (BNL-10591) PRODUCTION OF POLYETHYLENE AND RELATED COMPOUNDS BY RADIATION AT THE BROOKHAVEN NATIONAL LABORATORY. Metz, Donald J. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT(30-2)-Gen-16. 13p. (CONF-660312-7). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Nederlands Atoomforum Conference, Utrecht.

The underlying philosophy for studying the production of polyethylene and other compounds by radiation is discussed. Preliminary data obtained are given along with a list of copolymers with ethylene that have been formed. The economics of a plant constructed to produce polyethylene using cobalt-60 as the source of energy for initiating the reaction are also considered. (P.C.H.)

**95** (BNL-10592) SOME GENERAL PRINCIPLES IN THE RADIATION CHEMISTRY OF ORGANIC COMPOUNDS. Metz, Donald J. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT(30-2)-Gen-16. 26p. (CONF-660312-8). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From Nederlands Atoomforum Conference, Utrecht.

The similarities and differences between radiation chemistry and photochemistry are discussed, along with results obtained from two different methods for studying the radiation chemistry of organic compounds. The identification of intermediates, as studied by vinyl polymerization, is also considered. (P.C.H.)

**96** (CONF-660612-4) TRIPLET SAMPLED RADIATION DAMAGE. Weisz, S. Z.; Richardson, P.; Cobas, A. (Puerto Rico Nuclear Center, San Juan); Jarnagin, R. C. (North Carolina Univ., Chapel Hill). [1966]. Contract AT(40-1)-1833. 34p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From Symposium on Organic Scintillators, Argonne, Ill.

The emission produced by mutual annihilation of a pair of triplet excitons in single crystalline anthracene was observed to be an indicator of low level $\gamma$-dose. Under steady red light illumination the blue emission intensity $F_r$ is related to $\gamma$-dose D by $F_r^{-\frac{1}{2}} = a + bD$ in the range 300 to $10^4$ R. Independent measurements show the effect cannot be due to changes in absorption in the red region, changes in quantum yield of fluorescence, nor to changes in the specific rate of triplet interaction. An interpretation based on dose induced quenchers and the long range of triplet excitons is given. By use of multiple techniques an individual single crystal of anthracene can be used as a wide range dosimeter; triplet-triplet annihilation in the range $10^2$ to $10^4$ R, space charge limited photocurrent in the range $10^3$ to $10^6$ R, fluorescence quenching in the range $10^5$ to $10^8$ R, and absorption spectroscopy above $10^7$ R. (auth)

**97** (EUR-3058,e) KNOCK-OUT COEFFICIENT OF SINTERED URANIUM DIOXIDE. Gautsch, O.; Mustacchi, C. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Aug. 1966. 16p. Dep. mn.

Sintered $UO_2$ wafers facing a metal collector were irradiated at thermal neutron doses of about $5 \times 10^{18}$ n/cm$^2$. Quantitative analysis of the U deposits on the collector yielded a knock-out coefficient of 260 atoms (U + O) per average recoil fragment. (auth)

**98** (STI-DOC-11(Vol.4, No.2)) LIST OF BIBLIOGRAPHIES ON NUCLEAR ENERGY. (International Atomic Energy Agency, Vienna (Austria)). Sept. 1966. 36p. IAEA.

One hundred and forty-four bibliographies on nuclear energy are listed under general subject categories. An author index and corporate author index are included. (M.C.G.)

**99** HYPERFINE STRUCTURE OF POTASSIUM IN IRRADIATED $KAsF_6$. Wan, J. K. S.; Bernstein, H. J. (National Research Council, Ottawa). J. Chem. Phys., 45: 3479-80(Nov. 1, 1966).

Hyperfine interactions were observed in paramagnetic centers in $\gamma$-irradiated $KAsF_6$. Powdered samples of $KAsF_6$ irradiated at 77°K (1.3-MeV gammas) and examined at either 77°K, or at 300°K immediately after warmup, revealed only the presence of a very broad absorption. On heating the sample to 380°K for 1 hr, a well-resolved quartet of equally intense lines was obtained. The same spectrum was developed and observed if the irradiated sample was allowed to age in the room light for 30 hr. Single crystals gave essentially the same spectrum. It was concluded that the isotropic hyperfine structure must be due to interaction with a nucleus having a spin of $\frac{3}{2}$, $^{39}$K. (M.C.G.)

**100** THEORY OF RADIATION CHEMISTRY. VII. STRUCTURE AND REACTIONS IN LOW LET TRACKS. Mozumder, A.; Magee, J. L. (Univ. of Notre Dame, Ind.). J. Chem. Phys., 45: 3332-41(Nov. 1, 1966). (COO-38-397).

The low LET track of an electron is composed of a ran-

dom sequence of more or less isolated entities called spurs, blobs, and short tracks. The distribution function for these track entities was considered in detail by a Monte Carlo technique. In order to evaluate the effect of the more accurate structure on calculated chemical yields, as contrasted with the simpler spur model, the diffusion equations were solved numerically for the one radical case. The track model introduced has a high LET component embedded in it through the "short tracks." This investigation showed that for electron irradiations all LET effects result from the variation in fraction of energy deposited in short tracks. Effects of overlapping of various track entities during the diffusion and reaction phase are negligible. (auth)

**101** EVIDENCE FOR THERMAL HYDROGEN–ATOM REACTIONS IN IRRADIATED GASEOUS HCl. Davidow, R. S.; Lee, R. A.; Armstrong, D. A. (Univ. of Calgary, Alta.). J. Chem. Phys., 45: 3364-9(Nov. 1, 1966).

The addition of $SF_6$, which is known to have a high cross section for reaction with thermal electrons, reduces the hydrogen yield from irradiated gaseous HCl to $G(H_2) = 3.9$. The yield of hydrogen from pure HCl is $G(H_2) = 8.0$ and the reduction of 4.1 G units achieved by the $SF_6$ is within experimental error equal to $G_{ionization}$ for the system. Both $Cl_2$ and $Br_2$ cause a greater reduction to a residual or "unscavengable" hydrogen yield $G_{H''}$, of $2.2 \pm 0.2$ G units. In the case of $Cl_2$ this value is, within experimental error, independent of temperature over the range from −79 to 23°C. The addition of $Cl_2$ to $SF_6$–HCl mixtures of a composition such that virtually all electrons are scavenged by $SF_6$ causes a reduction from the $SF_6$ plateau to the same residual yield observed with $Cl_2$ and $Br_2$ alone. This reduction may be attributed to a competition between $Cl_2$ and HCl for thermal H atoms, which are formed in processes not involving thermal electrons as direct precursors. A competition kinetic study gave the following values of $k_{H+HCl}/k_{H+Cl_2}$: $8.7 \pm 0.5 \times 10^{-3}$ at 23°C; $7.5 \pm 0.5 \times 10^{-3}$ at 1°C; and $1.6 \pm 0.5 \times 10^{-3}$ at −77°C. The values at 23 and 1°C are in good agreement with recent experimental values of this ratio obtained by other methods. Possible origins of the thermal hydrogen atoms and the residual hydrogen yield are discussed. (auth)

**102** RADIATION POLYMERIZATION OF ETHYLENE IN ORGANIC SOLVENTS. 2. INFRARED ABSORPTION SPECTRA AND MELTING ENDOTHERMIC CURVES OF THE PRODUCTS. Yamabe, Masamori (Mitsubishi Petrochemical Co., Ltd., Japan); Shimizu, Harumichi. Yuki Gosei Kagaku Kyokai Shi, 24: 665-71(Aug. 1966). (In Japanese).

Liquid as well as solid polymeric products are obtained by radiation polymerization of ethylene in cyclohexane containing carbon tetrachloride. The infrared absorption spectra indicate that the liquid product is structurally similar to the telomer and its –C–C– chain is rather extended. The solid product begins to show the properties of polyethylene as the polymerization reaction progresses. In this reaction, the telomer first formed probably grows into solid product through liquid intermediate. The solid product consists of three types of components of varying melting points. The component of relatively low melting point resembles the liquid product, and it would probably change into the components with higher melting point as the reaction progresses. It is evident that some structural changes also take place as the molecular weight increases. (NSA of Japan)

**103** RADIATION POLYMERIZATION OF ETHYLENE IN ORGANIC SOLVENTS. I. EFFECTS OF CARBON TETRACHLORIDE ON POLYMERIZATION. Yamabe, Masamori (Mitsubishi Petrochemical Co., Ltd.); Shimizu, Harumichi. Yuki Gosei Kagaku Kyokai Shi, 24: 659-64 (Aug. 1966). (In Japanese).

Under ethylene pressure of 30 kg/cm², radiation polymerization of ethylene was conducted in an autoclave using cyclohexane containing a small amount of carbon tetrachloride as a solvent. The reaction mixture was exposed to the γ rays from cobalt-60 at a rate of 0.121 MRAD/hr and total irradiation of 0.24–6.06 MRAD at 20°C. Polymerization was found to proceed, in a stepwise manner, to form telomer, liquid products, and ultimately solid products. The reaction was accelerated in the presence of carbon tetrachloride, the mean molecular weight of the product being decreased at the same time. As in the case of the ethylene–carbon tetrachloride telomerization reaction, the products of this study probably contain four chlorine atoms per one polymeric molecule. (NSA of Japan)

**104** KINETICS OF THERMAL DEUTERIUM ATOM REACTIONS WITH METHANE AND ETHANE. Lawrence, Robert H. Jr.; Firestone, Richard F. (Ohio State Univ., Columbus). Contract AT(11-1)-1116. J. Amer. Chem. Soc., 88: 4564-70(Oct. 20, 1966).

Use of $NH_3$ as a proton (deuteron) scavenger permitted a study of the effects of temperature on homogeneous thermal D-atom reactions with $CH_4$ and $C_2H_6$ in $^3H$ β-irradiated gaseous $TD-D_2-CH_4-NH_3$ and $TD-D_2-C_2H_6-NH_3$ mixtures between 25 and 220°C. Exchange products with $CH_4$ are $CH_3D$, $CH_2D_2$, $CHD_3$, and $CD_4$, but ethane is not a detectable product below 125°C. $C_2H_5D$ is the only deuterated ethane formed by the atomic sequence in $D_2-C_2H_6-NH_3$ mixtures at 25 to 125°C. Exchange proceeds via H-atom abstraction in both systems. Above ~125°C a chain reaction sequence, $D\cdot + RH \rightarrow HD + R\cdot$ (i), $R\cdot + D_2 \rightarrow RD + D\cdot$ (ii), becomes dominant. Activation energies, $E_i$ and $E_{ii}$, were found to be $8.5 \pm 0.5$ and $12.0 \pm 0.7$ kcal/mole, respectively, for $RH = CH_4$, and $6.5 \pm 0.5$ and $13.5 \pm 1.0$ kcal/mole, respectively, for $RH = C_2H_6$. Estimates of $\Delta S^0$ and $\Delta H^0$ for i provide $k_{(D\cdot+CH_4)} = 6 \times 10^{-11} e^{-8500/RT}$ cc/molecule sec between 25 and 125°C and a collision theory (hard sphere, $\sigma = 3$ A, two squared terms) steric factor of 0.1. Results suggest that $D_2$ is inefficient as a third body for collisional stabilization of excited methane and ethane molecules formed via $R\cdot + D\cdot \rightarrow RD^*$, even at $D_2$ pressures near 1 atm. (auth)

**105** RADIOLYTIC SYNTHESIS OF PRUSSIC ACID BY IRRADIATION OF AMMONIUM AND HYDROCARBON MIXTURES BY ACCELERATED ELECTRONS. Dzantiev, B. G.; Trubnikov, V. P.; Popov, V. N. (Inst. of Chemical Physics, Academy of Sciences, USSR. Inst. of Nuclear Energy, Academy of Sciences, Belorussian SSR). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Tekh. Navuk, No. 3, 5-7 (1966). (In Russian).

Mixtures of $NH_3-CH_4$ and $NH_3-C_2H_4$ in a stainless steel vessel were irradiated with 600-keV electrons from an accelerator. The dose was determined by ionization chamber readings, or chemically by the amount of nitrogen oxides formed on irradiating air samples with the 600-keV electrons. After irradiation the irradiation vessel was flushed with a slow stream of air, and the hydrogen cyanide (HCN) was condensed out in a liquid nitrogen trap. The HCN content was determined photocolorimetrically from the reaction of bromine cyanide with a pyridine–benzidine complex in acid solution. The lower limit of detection was 0.1 μg HCN/ml. The G yield of HCN was 0.05 mols/100 eV of absorbed energy, which remained constant up to $10^{18}$ eV/ml. The maximum concentration of HCN in the mixture did not exceed 0.1%. The optimum composition was 80% $NH_3$–20% $CH_4$ in one system with a G yield of 0.07, and 60% $NH_3$–40% $C_2H_4$ in the other system with a G yield of ~0.045 molecules/100 eV. (TTT)

**106** RADIOSYNTHESIS OF PRUSSIC ACID BY IRRADIATION OF NITROGEN AND HYDROCARBON MIXTURES BY ACCELERATED ELECTRONS. Dzantiev, B. G.; Trubnikov, V. P. (Inst. of Chemical Physics, Academy of Sciences, USSR. Inst. of Nuclear Energy, Academy of Sciences, Belorussian SSR). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Tekh. Navuk, No. 3, 13-15(1966). (In Russian).

Mixtures of nitrogen with methane, ethylene, or acetylene were irradiated with 600-keV electrons from an accelerator. The maximum G yield of HCN was 0.03 for 50% $N_2$–50% ethylene, 0.05 for 50% $N_2$–50% acetylene, and 0.075 molecules/100 eV at an optimum composition of 80–90% $N_2$ and 10–20% $CH_4$. The addition of argon or helium to the nitrogen–methane mixture increased the G yield of HCN by a factor of two. The G yield of HCN increased with increasing gas pressure of the reactants. In principle these reactions can also be carried out in a reactor. (TTT)

**107** PRODUCTION OF PRUSSIC ACID BY IRRADIATION OF AMMONIUM AND HYDROCARBON MIXTURES IN ATOMIC REACTOR. Dzantiev, B. G.; Trubnikov, V. P.; Popov, V. N. (Inst. of Chemical Physics, Academy of Sciences, USSR. Inst. of Nuclear Energy, Academy of Sciences, Belorussian SSR). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Tekh. Navuk, No. 3, 8-12(1966). (In Russian).

Mixtures of ammonia with methane, ethylene, and acetylene were irradiated in a reactor under static conditions at pressures of 3 to 10 atm in polyethylene containers. The absorbed dose was determined using an ionization chamber, or chemically by using a gaseous $N_2O$ dosimeter. The thermal neutron flux was found, by activation of known amounts of NaF from the reaction $^{23}Na(n,\gamma)^{24}Na$, to be 0.35 to $2.7 \times 10^{12}$ neutrons $sec^{-1}$ $cm^{-2}$. In the ammonia–ethylene mixture, a maximum G yield of 0.02 molecules of HCN/100 eV was attained at a composition of 65% of $NH_3$–35% $C_2H_4$. The maximum G yield was ~0.031 molecules of HCN/100 eV at an optimum composition of 70% $NH_3$–30% acetylene. The maximum G yield was only 0.01 molecules/100 eV for a 60% $NH_3$–40% $CH_4$ mixture, but this yield rose to 0.045 molecules of HCN/100 eV on adding a small amount of activated charcoal to the system. The yield then tended to decrease slightly with increasing initial gas pressure of the reactants. The presence of small amounts of nitrogen oxides decreased the HCN yield practically to zero. It is believed that HCN is formed according to the following reactions: $N + C_2H_4 \rightarrow (C_2H_4N) \rightarrow HCN + CH_3$; $C_2H_5NH_2^* \rightarrow HCN + CH_4 + H_2$; and $N + C_2H_4 \rightarrow (C_2H_2N) \rightarrow HCN + CH$. Ethylene also tended to form a polymer on being irradiated in the presence of ammonia. (TTT)

**108** RADIOCHEMICAL CHANGES OF STEARIC ACID. Kaplan, Gustav (Vojenska Akademie Antonina Zapotockeho, Brno). Jad. Energ., 12: 302-7(1966). (In Czech).

The changes of some physical properties, softening temperature, index of refraction, dielectric constant, plasticity, and infrared absorption spectrum maxima of stearic acid exposed to $\gamma$ radiation in the presence of air are described. (tr-auth)

**109** EFFECT OF TEMPERATURE AND DOSE ON RADIATION OXIDATION OF ISOOCTANE (2,2,4-TRIMETHYLPENTANE). Saraeva, V. V.; Kung, Chen-ching. Vestn. Moskov. Univ., Ser. II: Khim., No. 4, 14-19(July-Aug. 1965). (In Russian).

Graphs are presented for the yield of peroxides, carbonyl compounds, alcohols, acids, and esters as a function of temperature from –78 to +90°C at a constant dose of $2.3 \times 10^{15}$ eV/ml·sec for the first three and $7.6 \times 10^{15}$ eV/ml·sec for the last two. For the first three the yield changed little up to 20, 40, and 60°C, respectively, but then began to rise; for the last two there was no temperature dependence. When the temperature was held constant, changing the dose from $2.3 \times 10^{14}$ to $2.6 \times 10^{16}$ eV/ml·sec for peroxides and from $7.0 \times 10^{14}$ to $4.0 \times 10^{15}$ eV/ml·sec for carbonyl compounds did not affect the yield until the temperature was set above 20°C. For alcohols dose dependence was not shown below 80°C, and for acids it was not shown below 90°C. The data obtained in these experiments together with published data for other hydrocarbons indicated that the ratio of reaction rate constants is the same for all saturated hydrocarbons. However, for unsaturated ones the ratio is higher. (TTT)

**110** RADIOCHEMICAL POLYMERIZATION OF ISOPRENE–METHYL METHACRYLATE MIXTURES. Hinschberger, Andre; Vacherot, Monique; Marchal, Jean (Centre de Recherches sur les Macromolecules, Strasbourg). Compt. Rend., Ser. C, 263: 620-3(Aug. 29, 1966). (In French).

The radiochemical polymerization of isoprene–methyl methacrylate mixtures was studied at 25 and at –16°C. The coexistence of a cationic mechanism and a radical mechanism for the polymerization of isoprene during irradiation was confirmed. (tr-auth)

**111** RADIOTHERMOLUMINESCENCE OF 4,4'-DIMETHYLBENZOPHENONE. Marans, N. S.; Wessells, F.; Olfky, S. (W. R. Grace and Co., Clarksville, Md.). Nature, 211: 1176-7(Sept. 10, 1966).

The effects of radiation dose on 4,4'-dimethylbenzophenone were tested with 2-Mev electrons from a Van de Graaff accelerator with a dose range from 2 to 20 MRAD. The effects of melting, oxygen, storage conditions, and time lapse between irradiation and radioluminescence measurements were studied. Behavior on re-irradiation showed that thermoluminescence did not remain constant but increased as a function of the number of exposures. (P.C.S.)

**112** RADIATION RESISTANCE OF CERTAIN POLYPHENYLALKANES. Vasil'ev, G. K.; Chel'tsova, M. A.; Chkheidze, I. I. (Inst. of Chemical Physics, Academy of Sciences, USSR. Zelinskii Inst. of Organic Chemistry, Academy of Sciences, USSR). Kinet. Kataliz, 7: 769-70 (July-Aug. 1966). (In Russian).

Results of EPR and mass spectrometric measurements of the yields of radicals ($G_R$) and hydrogen ($G_H$) from low-temperature radiolysis of various polyphenylalkanes irradiated by 1.6-Mev electrons indicated a high radioresistance of these materials. Tabulated data for $G_H$ and $G_R$ at –150°C show $8.5 \times 10^{-3}$ to $2.3 \times 10^{-4}$ and 0.1 to 0.03 per 1/100 ev, respectively. The EPR spectra produced by irradiations of the compounds were practically identical; they exhibited triplet with an intense central component (1 : 2 : 1) and total resolution of ~95 oersteds. (R.V.J.)

**113** STUDY OF OPTICAL PROPERTIES OF CARBOHYDRATES SUBJECTED TO $\gamma$ IRRADIATION IN SOLID STATE. Generalova, V. V.; Kishinevskaya, M. B.; Polak, G. V. Zh. Prikl. Spektrosk., Akad. Nauk BSSR, 5: 81-4 (July 1966). (In Russian).

Investigation results are given for a number of optical properties (absorption spectra in the ultraviolet, optical activity, and refractive index) of some carbohydrates (glucose, sacharose, maltose) subjected to $\gamma$-irradiation by $^{60}Co$ in the crystalline state. The irradiation influence was studied in the absorbed dose range $10^6$–$10^9$ rad, at different thermodynamic conditions the dose power being 400 rad/sec. A comparison was carried out of the direct and the indirect radiation effect on carbohydrates irradiated in the crystalline state and in aqueous solution. (auth)

**114** GRAFTING OF METHYL METHACRYLATE TO BUTYL RUBBER UNDER THE INFLUENCE OF GAMMA RADIATION. Tashmukhamedov, S. A.; Tillaev, R. S.; Latypov, T.; Usmanov, Kh. U. (Tashkent State Univ.). Uzbek. Khim. Zh., No. 5, 59-62(1965). (In Russian).

Graft copolymers of butyl rubber (copolymer of isobutylene with 2.0 to 3.0% isoprene) with methyl methacrylate were synthesized radiochemically by simultaneously irradiating a mixture of the polymer and monomer in the absence of atmospheric oxygen with $^{60}Co$ gamma rays. After extraction of the polymethyl methacrylate homopolymer (PMMA), the degree of grafting and yield of the graft copolymer decreased with increasing irradiation dose for a polymer-to-monomer ratio of 1 : 1 and 1 : 0.6, and also in the solvent dichloroethane. The copolymers formed had a variable composition; their formation was confirmed by turbidimetric titration. A study of the kinetics of swelling of the copolymers in various liquids showed that the nature of the side chain in the graft copolymer causes a decrease in the affinity of the system obtained for some liquids and an increase for others. A study of the viscosity of solutions of the graft copolymers in benzene at 30°C revealed that as the content of graft PMMA in the copolymer diminishes (with rising irradiation dose), the intrinsic viscosity of the solutions decreases. This is attributed not only to a drop in the proportion of graft PMMA in the copolymer but also to the degradation of macromolecules of the initial polymer under the influence of gamma radiation. (ATD)

**115** RADIATION-INDUCED CHEMISORPTION OF OXYGEN ON $\gamma$-$Al_2O_3$. Kolbanovskii, Yu. A.; Masterova, M. N. (Inst. of Petroleum-Chemical Synthesis, Academy

of Sciences, USSR). Kinet. Kataliz, 7: 727-31(July-Aug. 1966). (In Russian).

Studies of kinetics of radiation-chemical sorption of oxygen on $\gamma$-$Al_2O_3$ at 20°C showed that the initial rate of the reaction is not influenced by the pressure of the oxygen. A simple scheme for the chemisorption is given, indicating radiochemical yield of adsorption centers equal to 4 per 100 eV and the ratio of constants of chemisorption and active center destruction equal to $(3.66 \pm 0.26) \times 10^{-16}$ $cm^3$. (R.V.J.)

**116** RADIATION CONSERVATION OF AMINO ACIDS UPON INTERACTION WITH RECOIL TRITIUM ATOMS. Simonov, E. F.; Nesmeyanov, An. N. Vestn. Moskov. Univ., Ser. II: Khim., No. 5, 28-30(Sept.-Oct. 1965). (In Russian).

The effect of 15 min irradiation with a neutron flux of $0.87 \times 10^{13}$ n/$cm^2$-sec on dl-methionine, l-cysteine, and l-glutamic acid in the presence of 9 to 91% lithium carbonate was studied. The HT activity for all three amino acids was maximum with 50% lithium salt. For glutamic acid, the fraction of activity appearing in the gas phase as $CH_3T$ increased linearly from 10 to 63% as the lithium salt concentration was decreased from 80 to 9%. Preservation of both methionine and cysteine was highest, 63 and 59%, respectively, with 33% lithium salt present. After irradiation, the condensed phase contained seventeen decomposition products that reacted positively with Ninhydrin. These products included glutaric acid, $\alpha$- and $\gamma$-amino fatty acids (particularly $\alpha$-), pyrollidone carbonic acid, and serine. The serine was formed by a secondary process during analysis. (TTT)

**117** STEREOSPECIFIC RETENTION IN cis- AND trans-ISOMERS OF COBALT COMPLEXES. Wolf, Gerhard K. (Univ., Heidelberg). Radiochim. Acta, 6: 39-43(Aug. 1966). (In German).

In cis- and trans-$[Co(ethylenediamine)_2Cl_2]NO_3$ recoiling, atoms of $^{60}Co$ and $^{58}Co$ respectively with extremely varying recoiling energy were produced by using fast and thermal neutrons. At the small recoiling energy (10 to 100 ev) of the $^{60}Co$ atoms only the parent substance is formed stereospecifically besides $Co^{2+}$. After subsequent annealing an exclusively stereospecific formation of the parent substance out of $Co^{2+}$ ensues. At the high recoiling energy (to $10^5$ ev) of the $^{58}Co$ atoms a small yield of the other stereoisomer is also found along with other products. Subsequent annealing causes an increase of all products. In nuclear reactions with thermal neutrons the energy transferred locally to the lattice does not suffice to effect the necessary exchange reactions of the ligands. Such processes are possible only in nuclear reactions involving neutrons of high energy. (auth)

**118** THERMOMECHANICAL PROPERTIES OF IRRADIATED POLYAMIDES CROSS LINKED BY CHROMIUM CHLORIDE. Afanas'ev, A. M.; Pavlov, S. A. (Moscow Technological Inst. of Light Industry). Izv. Vyssh. Ucheb. Zaved., Khim. Khim. Tekhnol., 9: 480-5 (1966). (In Russian).

The influence of cross-linking chromium compounds followed by irradiation on the thermomechanical properties of mixed polyamide films was studied. Addition of chromium chloride transformed the film structure from amorphous-crystalline to amorphous increasing the heat resistance of the film. At 25 to 300°C the film lost its fluidity; however, under integral $\gamma$ doses of 500 MRAD the polyamide films containing chromium chloride increased their cold-fluidity and at temperatures close to melting turned into a viscous fluid. It was indicated that radiation doses exceeding by an order of magnitude the doses capable of producing gels of the initial polyamides are necessary to produce even small gel links between the macromolecules of the polyamide films cross-linked by chromium(III) salts. (R.V.J.)

**119** STUDIES ON RADIATION-INDUCED IONIC POLYMERIZATION. II. EFFECT OF SOLVENT ON THE POLYMERIZATION OF ISOBUTENE AT LOW TEMPERATURE. Ueno, K.; Yamaoka, H.; Hayashi, K.; Okamura, S. (Kyoto Univ.). Int. J. Appl. Radiat. Isotop., 17: 595-602(Oct. 1966).

The radioinduced polymerization and co-polymerization of isobutene with styrene was studied in several solvents at −78°C. The rates of polymerization of isobutene in $CH_2Cl_2$, $CHCl_3$, and n-hexane had similar values, but in $CS_2$ a higher value was obtained. It was concluded that no relationship exists between the dielectric constant of solvents and the rate of polymerization. From the magnitude of the G-values (0.1 to 0.2) it was supposed that the growing chain is initiated by a free ion (G = 0.1 to 0.2). Monomer reactivity ratios in the polymerization of isobutene with styrene appeared to be similar to those obtained in the case of conventional cationic polymerization. The radioinduced polymerization rates for several monomers in $CH_2Cl_2$ at −78°C were found to lie in the following order: isobutene > styrene > p-methoxystyrene > isoprene ≒ $\alpha$-methyl styrene > isobutyl vinyl ether > 2-chloroethyl vinyl ether > $\beta$-propiolactone. (auth)

**120** REACTIONS OF ENERGETIC CARBON ATOMS WITH NITROGEN MOLECULES. Ache, H. J.; Wolf, A. P. (Brookhaven National Lab., Upton, N. Y.). Radiochim. Acta, 6: 32-9(Aug. 1966). (BNL-9814).

The reactions of "hot" carbon atoms produced by the $^{14}N(p,\alpha)^{11}C$ process were studied in nitrogen–hydrogen and nitrogen–hydrocarbon systems. $H^{11}CN$ was the only "primary" nitrogen-containing compound that could be detected. It was formed by carbon atoms having energies above the thermal range. The evidence indicates that in the first step non-thermal carbon atoms react with $N_2$ to give $CN^*$, which in a second very fast reaction enters stable form by hydrogen abstraction from the surrounding molecules to give HCN. Adding oxygen to the reaction mixture causes the $H^{11}CN$ to be sharply reduced due to the competition between $N_2$ and $O_2$ for the "hot" $^{11}C$ atoms to form $^{11}CN^*$ and $^{11}CO$ respectively. The "reaction cross section" for the formation of $^{11}CO$ proved to be nine times that for $^{11}CN^*$ formation. A second major product observed in these nitrogen–hydrocarbon mixtures was acetylene-$^{11}C$. The acetylene-$^{11}C$ produced in non-thermal reactions could be evaluated by adding oxygen as scavenger. The "reaction cross section" for acetylene formation was compared in the systems: ethane–nitrogen and propane–nitrogen. With increasing amounts of rare gas moderators such as helium or neon, added to the nitrogen–hydrocarbon mixtures, the $H^{11}CN$ decreased, confirming the hypothesis that energies above thermal in one of the reactants are required to bring about reaction between nitrogen molecules and carbon atoms. (auth)

**121** RECOIL-CHEMICAL BEHAVIOR OF IRIDIUM IN SOLUTIONS OF $Na_2IrCl_6$ COMPLEXES AFTER (n,$\gamma$) PROCESSES. Bell, R.; Herr, W. (Kernforschungsanlage, Juelich, Ger. Univ., Cologne). Radiochim. Acta, 6: 43-7 (Aug. 1966). (In German).

The $^{192}Ir$- and $^{194}Ir$-labeled products arising from the $^{191}Ir(n,\gamma)^{192}Ir$ and $^{193}Ir(n,\gamma)^{194}Ir$ process in neutron-irradiated solutions of $Na_2IrCl_6$ were studied by paper electrophoresis. The number, nature, and yield of the recoil products were compared with those appearing in the crystalline system, $Na_2IrCl_6 \cdot 6H_2O$. The electrophoretical and chemical behavior suggest that the final stabilized products formed in solution are mainly octahedral aquo- and aquochloro-complexes of Ir(III) with cationic and neutral character, respectively. The product distribution shows a marked dependence on the chloride ion concentration. In contrast to the 2.2% retention ($Ir^{IV}Cl_6^{--} + Ir^{III}Cl_6^{---}$) found in the crystalline system (cage effect), in solution <0.1% of the radioactive iridium appears as hexachlorocomplex. (auth)

**122** RADIOLYSIS OF CHLOROCARBONS. Rabovskaya, N. S.; Kogan, L. M.; Nikolaeva, A. A. Vestn. Moskov. Univ., Ser. II: Khim., No. 4, 42-3(July-Aug. 1965). (In Russian).

Three representative unsaturated chlorocarbons were gamma-irradiated: hexachloropropylene with one double bond (I), octachloropentadiene-1,3 with two double bonds (II), and the cyclic isomer octachlorocyclopentene (III).

Compound I showed 57% radiolysis at a dose of $6.85 \times 10^{22}$ eV/ml, with the product yield decreasing from 4.7 to 3.5 molecules/100 eV in going from 3.24 to $10^{22}$ to $6.85 \times 10^{22}$ eV/ml. The radiolysis product considered of four crystalline substances (dichloromethylenehexachlorocyclopentene, hexachloroethane, octachloropropane, and an unknown but probably cyclic chlorocarbon) and a mixture of oligomers containing less chlorine than the starting material. Chromatographic studies on the fraction containing the lighter components showed no significant amounts of $CCl_4$ or $C_2Cl_4$. Compound II was more radiation resistant, and with a dose of $6.1 \times 10^{22}$ eV/ml showed 31% radiolysis, with hexachloroethane and a mixture of oligomers as the product but no $CCl_4$ or $C_2Cl_4$. Compound III was very stable to radiation. (TTT)

**123** REACTION OF TRITIUM RECOIL ATOMS WITH α-ALANINE DERIVATIVES. Simonov, E. F.; Nesmeyanov, An. N. Vestn. Moskov. Univ., Ser. II: Khim., No. 2, 32-3(Mar.–Apr. 1966). (In Russian).

Data obtained during irradiation of serine, cysteine, asparagine, tryptophane, and β-phenyl-α-alanine showed that the nature of the functional group, that is, the importance of the C-X bond energy, does not affect either the radiation resistance of the amino acid or the radiochemical product yield. The activity distribution between the gaseous and condensed phases of the product differed greatly. The ability of the functional groups to "scintillate" the excess energy of the C-X bond appeared to be in the order COOH > OH > SH. No conclusions were reached with regard to the phenol and indole groups inasmuch as they are very different in type from the other groups. The presence in these groups of a large number of nonlabile hydrogen atoms should be indicated in the activity distribution of the product phases. (TTT)

**124** THE GAMMA RADIATION OF METHANE, AMMONIA, AND WATER. Ponnamperuma, Cyril (Ames Research Center, Moffett Field, Calif.). 8p. (CONF-650560–20). ORAU.

From 13th Annual Meeting of the Radiation Research Society, Philadelphia.

Preliminary studies were made in an attempt to trace the path of chemical evolution before life appeared on earth. It appears that the components of Earth's primitive atmosphere of ammonia, methane, and water interacted with different forms of energy to give rise to organic material. Quantitative experiments were performed using these basic components and gamma radiation as the source of energy. Chromatographic analysis of end products showed the formation of a number of organic compounds including hydrogen cyanide and formaldehyde. The pathway of production of the basic constituents of nucleic acid and protein molecules seems to be fairly straightforward, although possibly oversimplified—the hydrogen cyanide giving rise to the bases, the aldehyde giving rise to the sugars, and the hydrogen cyanide and aldehyde together giving rise to amino acids. (J.G.B.)

**125** POLYMERIZATION OF TRIBUTYLVINYL-PHOSPHONIUM HALIDES BY IONIZING RADIATION. Chen, Catherine Shuihua Hsia (to American Cyanamid Co.). U. S. Patent 3,269,930. Aug. 30, 1966. Filed Sept. 20, 1963.

A method for the production of high-molecular-weight polymers of a vinyl phosphonium halide, particularly chlorides, bromides, and iodides, comprises contacting the solid-state monomer with ionizing radiation at a dosage rate of about 0.1 to about 10.0 Mrads/hr at a temperature ranging from about –80 to 150°C. (B.L.M.)

**126** RADIATION INDUCED GRAFT COPOLYMERIZATION. Das Gupta, Sharda; Slobodian, James T. (to Atomic Energy of Canada Ltd.). Canadian Patent 742,194. Sept. 6, 1966.

A process is described for the graft copolymerization of a vinyl monomer in solution to linear shaped articles of polymeric material, such as fabrics, threads, and sheets. Nylon, cellulose, and paper rolled on a rod are immersed in the vinyl monomer solution and exposed to gamma radiation, such as a $^{60}Co$ source. Homopolymers form mainly in the outer layers of the roll and must be extracted with an organic solvent or discarded. The major portion of the roll, however, requires no extraction treatment. Seven examples are given to indicate the details of processing. (F.S.A.)

**127** METHOD FOR GRAFT-COPOLYMERIZING BUTADIENE ON TO POLYOLEFINS. Ohashi, Hachiro (to Nippon Telegraph and Telephone Public Corp.). Japanese Patent 1965-21272. Sept. 21, 1965. Filed Aug. 18, 1962.

In the method proposed for the graft-copolymerization of butadiene and polyolefins, polyolefins are irradiated with high-energy ionizing radiation in the temperature range of 20 to 80°C while in contact with butadiene vapor. Later investigations showed that the method may be applicable to industrial production. (NSA of Japan)

**128** METHOD FOR PRODUCTION OF IMPROVED POLYOXYMETHYLENES. Miyazaki, Kagayaki (to Asahi Chemical Industry Co., Ltd.). Japanese Patent 1965-21278. Sept. 21, 1965. Filed Oct. 25, 1962.

A method is proposed for the production of polyoxymethylenes with improved properties. Polyoxymethylene of high molecular weight has good thermal stability and is a valuable material for fabrication of various articles. By the method proposed improved polymers of high molecular weight and excellent thermal stability can be obtained. The polyoxymethylene structure is the main component of the polymer chains. The polymers, which are constructed by the mixture of oxymethylene polymer, polymers of unsaturated acid amides including their derivatives and homologues, and copolymers of oxymethylene and acid amides, are produced by the solid state radioinduced polymerization of trioxane and unsaturated acid amides with ionizing radiation. (NSA of Japan)

**129** METHOD FOR ANTISTATIC TREATMENT OF FABRICATED ARTICLES OF α-OLEFIN POLYMERS. Ueno, Jiroo (to Sekisui Chemical Co., Ltd.). Japanese Patent 1965-21150. Sept. 20, 1965. Filed June 30, 1962.

A method is proposed for antistatic treatment of fabricated articles of α-olefin polymers. An antistatic quality of long durability can be obtained for α-olefin polymers such as polyethylene and polypropylene. A thin film of silicic acid or silica is attached on the surface of the articles of α-olefin polymers, after which they are irradiated with ionizing radiation in contact with acrylonitrile. (NSA of Japan)

**130** METHOD FOR PRODUCING CATION-EXCHANGE MEMBRANES. Nagaoka, Haruo (Inst. of Physical and Chemical Research). Japanese Patent 1965-21157. Sept. 20, 1965. Filed Apr. 12, 1962.

A method is proposed for producing cation-exchange membranes. Vinyl acetate is graft polymerized with powders or films of synthetic resins by irradiating them with ionizing radiation in contact with the monomer vapor. In the case of powders, they are fabricated into films after grafting. The vinyl acetate-grafted films are treated by deacetylation of the acetate group in the grafts, followed by esterification of the hydroxyl group thus formed by sulfuric acid, etc. to introduce ion-exchange groups into the polymer structure. By the method, which is industrially applicable, strongly acidic cation-exchange membranes with excellent electrochemical properties and high mechanical strength can be obtained. (NSA of Japan)

## Radiochemistry

*Refer also to abstracts 104 and 121.*

**131** (ORNL-TM-1584) DEVELOPMENT OF PROCESSES FOR SOLIDIFICATION OF HIGH LEVEL RADIOACTIVE WASTE: SUMMARY FOR POT CALCINATION AND RISING LEVEL POTGLASS PROCESSES. Clark,

W. E.; Suddath, J. C.; Hancher, C. W.; Blanco, R. E.; Godbee, H. W.; Holmes, J. M.; Fitzgerald, C. L. (Oak Ridge National Lab., Tenn.). Aug. 12, 1966. Contract W-7405-eng-26. 132p. Dep. mn. CFSTI $4.00 cy, $1.00 mn.

Developmental work on solidification of aqueous radioactive wastes by two batch or semi-continuous processes, pot calcination (Potcal process) and rising level glass (RL-Potglass process), is summarized. The Potcal process has been completely developed through laboratory and full engineering-scale demonstrations on a wide variety of waste types. Solidification of actual radioactive waste on an engineering-scale remains to be demonstrated on these waste types in full engineering-scale equipment, but further developmental work is needed to define compositional parameters which can be allowed for each waste type. The principal limiting factor is the corrosivity of the melt at the operating temperature. (auth)

**132** TRANSPLUTONIUM ELEMENTS. Stary, Jiri; Caletka, Rostislav (Cs. Vysoke Uceni Technicke, Prague. Inst. of Nuclear Research, Rez, Czech.). Chem. Listy, 60: 1267-96(Sept. 1966). (In Czech).

The preparation, separation, and chemical and radiochemical properties of the transplutonium elements are reviewed. Tables of isotopes, separation factors, extraction constants, and stability constants of complexes of transplutonium elements are presented. (138 references) (tr-auth)

**133** CHEMICAL YIELDS OF NUCLEAR REACTIONS OF BROMINE AS AN INDICATION OF AGGREGATION AND COMPLEXING OF BROMINE IN ORGANIC MATRICES AT 77 DEG K. Iyer, R. M.; Willard, J. E. (Univ. of Wisconsin, Madison). Contract AT(11-1)-32. J. Amer. Chem. Soc., 88: 4561-4(Oct. 20, 1966). (COO-32-117).

Organic yields from the $^{80m}$Br isomeric transition indicate that when solutions of bromine in n-hexane are frozen to a polycrystalline solid at 77°K the bromine is dispersed as $Br_2$ at concentrations of $2 \times 10^{-5}$ mf(mole fraction) and below, but is present as $(Br_2)_n$ clusters of nearly uniform size at all concentrations in the range of $5 \times 10^{-4}$ to $1 \times 10^{-2}$ mf. Formation of these clusters appears to be dependent on a preferred size of $Br_2$ aggregate in the crystal lattice, rather than an equilibrium of the type $nBr_2 \rightleftharpoons (Br_2)_n$ in solution. Alkyl halides, benzene, and ethanol, at concentrations equivalent to the bromine, lessen clustering by complex formation. Similar clustering of bromine occurs in polycrystalline n-pentane but not in glassy 3-methylpentane or in polycrystalline benzene. The organic yield from the $^{79}$Br(n,$\gamma$)$^{80m}$Br process in $(Br_2)_n$ clusters in polycrystalline n-$C_6H_{14}$ is lower than that from the $^{80m}$Br $\rightarrow$ $^{80}$Br isomeric transition process, suggesting that the recoil atom may not escape its parent cage and that radiolytic effects following internal conversion contribute more effectively to the organic yield than does recoil energy. Bromine, but not $I_2$, reacts with the stable unsaturated products formed by radiolysis of polycrystalline n-$C_6H_{14}$ by reactor radiations. The extent of this reaction is the same when the bromine is added after melting the irradiated solid as when it is present during irradiation, indicating the absence of reaction with free radicals. (auth)

**134** CALCULATION OF EFFICIENCY OF FISSION FRAGMENT SOURCE IN STACKED FOIL CONFIGURATION. Litvinenko, B. A. (Inst. of Nuclear Power Engineering, Academy of Sciences, Belorussian SSR). Vestsi Akad. Navuk BSSR, Ser. Fiz.-Tekh. Navuk, No. 3, 16-19 (1966). (In Russian).

The fraction of fission fragment energy ($\epsilon_1$) leaving a foil was determined by the thickness of the uranium layer $\delta$ and the range of the fragment R in the layer as follows: $E(x)/E_0 = [1-(x/R)]^n$, where n is the equal to 2 or $^3/_2$. The fraction of energy leaving the layer over an element of solid angle $d\Omega$ will be: $d\epsilon_1 = [E(x)/E_0]\,(dx/\delta)\,(2\pi \sin\theta\, d\theta/4\pi)$. On integrating, it is found for $n = 2$ that $\epsilon_1 = 1-(p/2)-p^2/3 + p^{1/2}p$ where $p = \delta/R$ and $p < 1$. It is found that $\epsilon_1 = {}^1/_6p$ for $p > 1$. A more complicated expresssion is obtained for $n = {}^3/_2$. Values of $\epsilon_1$ are plotted as a function of the reduced foil thickness p, and compared with experimental values of $\epsilon_1$ obtained from the fixation of nitrogen on the assumption that the G yield of $NO_2$ is equal to 3.1 molecules /100 eV of absorbed energy. Agreement is reasonably good at various values of p. An expression is given for calculating the efficiency of a stacked foil. (TTT)

**135** PREPARATION OF RADIOACTIVE TRACERS. Rudenko, N. P.; Kalinkina, O. M. Vestn. Moskov. Univ., Ser. II: Khim., No. 6, 83-5(Nov.-Dec. 1965). (In Russian).

The application of the radioisotopes $^{47}$Sc, $^{45}$Ti, $^{57}$Ni, and $^{67}$Cu as isotopic tracers and their convenient preparation were investigated. The ($\gamma$,n) reaction was found suitable for preparing $^{45}$Ti and $^{57}$Ni, while the ($\gamma$,p) reaction was chosen for $^{47}$Sc and $^{67}$Cu. The targets were irradiated in the betatron at dose rates ranging from 10 to 50 R/min. Titanium oxide enriched in $^{46}$Ti, natural, metallic Ni, and ZnO enriched in $^{68}$Zn were used as targets. The radioisotopes were determined by halflife measurements. The scandium isotope may be prepared without a carrier. $^{57}$Ni possesses more favorable radiometric properties than the usually used $^{63}$Ni; the much longer half life of $^{67}$Cu than that of $^{63}$Cu and its carrier-free preparation renders this isotope a valuable tool for tracer studies. After irradiation, it was separated from the ZnO target by extraction with a chloroform solution of dithizone. (TTT)

**136** IODINE SOURCE FOR BETA COUNTING. Delucchi, A. A.; Greendale, A. E. (Naval Radiological Defense Lab., San Francisco). Radiochim. Acta, 6: 47-9 (Aug. 1966).

A simple, fast method was developed for producing iodine sources weighing a fraction of a milligram that are useful for beta counting. This method gives high chemical yields and results in uniform sources having good physical and chemical stability. The method does not give good yields with thin films suitable for 4 $\pi$-beta counting. However, the lightness, uniformity, and stability of these sources should satisfy most 4 $\pi$-beta counting requirements. (auth)

**137** REACTIONS OF HOT ATOMS IN CONDENSED SYSTEMS. Nesmeyanov, An. N. Vestn. Moskov. Univ., Ser. II: Khim., No. 6, 3-16(Nov.-Dec. 1965). (In Russian).

The mechanism of hot-atom reactions was investigated, in order to develop a theoretical basis for the hot synthesis of labeled compounds. Examining the substitution of H atoms by hot Br atoms in bromobenzene, it was found that the recoil atoms of Br react at energy ranges at which only steric hindrance plays a role. Reactions involving the substitution of hydrogen by heavier recoil atoms in the energy region above the thermal one take place by an inelastic collision of the atom with the whole molecule. Substitution of hydrogen by recoil atoms, forming HT and $CH_3T$ molecules, follows the mechanism postulated by R. Wolfgang; other reactions of recoil atoms with organic molecules result in the formation of excited molecules or of an intermediate excited complex. Inter- and intramolecular energy transfer is involved in the decrease of the excitation energy. The bond energy of atoms and molecules does not affect the substitution reactions in the elastic collision range but it becomes important in the energy range above the thermal one. An isotopic effect related to the ion–molecular reactions in the condensed state was discovered. It was also found that recoil atoms in solids follow complex transformations forming thermodynamically stable states of the element and also an electron-deficient structure together with lower-valence forms of the element. (TTT)

**138** NOBLE GAS COMPOUNDS IN RADIOCHEMISTRY. Adloff, J. P. (Centre de Recherches Nucleaires, Strasbourg). Radiochim. Acta, 6: 1-9(Aug. 1966). (In French).

Radiochemistry has to deal in its various fields with the noble gas compounds. The following aspects are considered: radon chemistry, radioinduced and radiosynthesis of these compounds, Szilard-Chalmers effect, and application of Mössbauer spectrometry to the investigation of the chemical state of nascent rare gas atoms. Possible formation of radon compounds as a result of the disintegration of radium is also discussed. (auth)

**139** STUDY OF THE CHEMICAL EFFECTS OF NUCLEAR DECAY. I. MECHANISM OF THE REACTIONS FOLLOWING THE DECAY OF A TRITIUM ATOM IN A MOLECULE OF METHANE-$T_4$. Cacace, Fulvio; Ciranni, Giovanna; Guarino, Angelo (CNR, Rome. Univ., Rome). Atti Accad. Naz. Lincei, Rend., Cl. Sci. Fis., Mat. Natur., 40: 264-70(Feb. 1966). (In Italian).

The chemical consequences following beta decay of a tritium atom contained in an organic molecule were studied with a tracer technique based on the use of multilabeled molecules, such as methane-$T_4$. When $CT_4$ is allowed to decay in systems at atmospheric pressure the labeled decay fragments react with the surrounding molecules giving tritiated products that were analyzed by radio gas chromatography. The results, combined with the available mass spectrometric information on the decay-induced fragmentation of monotritiated methane, were used to derive a detailed model of the chemical reactions induced by the nuclear event. The results suggest that the decay of multilabeled molecules can afford a valuable tool to study the reactions of ionic species in systems at high pressure or even in the liquid state. (auth)

**140** PRODUCTION OF $^{131}I$. Case, F. N.; Acree, E. H. (to U. S. Atomic Energy Commission). U. S. Patent 3,282,655. Nov. 1, 1966.

A method is given for preparing $^{131}I$ by dissolving an irradiated target material containing $^{131}I$ with caustic solution, filtering the resulting caustic solution to remove solids, acidifying the resulting filtrate with sulfuric acid while sparging with an oxygen-containing gas, and recovering the $^{131}I$ produced in purified form. (AEC)

## Separation Processes

*Refer also to abstracts 59, 132, and 391.*

**141** (AD-635643) ELEMENTARY INTRODUCTION TO ISOTOPE SEPARATION. Holliday, Dennis; Plesset, Milton S. (RAND Corp., Santa Monica, Calif.). June 1966. Contract AF49(638)-1700. 38p. (RM-4938-PR). CFSTI $2.00 cy, $0.50 mn.

Six isotope separation processes are discussed: the separation nozzle; sweep diffusion; thermal diffusion; electromagnetic separation; gaseous diffusion; and centrifugation. The emphasis is on the physical principles involved in each process and on the use of these physical differences. Because five of the processes involve devices that give individually a very small separation, a cascade of these devices is required to effect large separations. The steady-state theory of such cascades is also discussed. (auth)

**142** (DP-1047) CATION EXCHANGE CONCENTRATION OF AQUEOUS $^{233}UO_2(NO_3)_2$ AND CONVERSION TO $^{233}UO_3$. Burney, Glenn A. (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.). July 1966. Contract AT(07-2)-1. 24p. Dep. mn.

A process was developed to isolate $^{233}U$ from the dilute uranyl nitrate solution that is produced by solvent extraction separation of $^{233}U$ from irradiated thorium. The uranium is concentrated by cation exchange, precipitated from the cation exchange eluate as ammonium uranate, and finally converted to uranium trioxide by calcination. (auth)

**143** (EUR-2578.e) ISOLATION OF MICROGRAM AMOUNTS OF BERKELIUM AND CALIFORNIUM FROM IRRADIATED AMERICIUM. Kooi, J.; Gandolfo, J. M.; Waechter, N.; Wijkstra, J. (European Atomic Energy Community); Boden, R.; Hecq, R.; Vanhoof, E.; Leynen, M. (Centre d'Etude de l'Energie Nucleaire, Mol (Belgium)). Dec. 1965. 46p. Dep. mn.

A description is given of the processing of a slug containing 2.5 grams of highly irradiated $^{241}Am$ from which approximately 200 milligrams of curium and microgram-quantities of berkelium and californium were isolated. The processing included full-scale application of an extraction chromatography procedure using HDEHP-loaded columns. (auth)

**144** (GA-7107) PRELIMINARY DESIGN FOR A HEAD-END REPROCESSING FACILITY INTEGRAL WITH AN HTGR POWER PLANT. Steyer, K. G.; Stelling, H. E. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Apr. 29, 1966. Contract AT(04-3)-167. 19p. (CONF-660524-22). Dep. mn. CFSTI $1.00 cy, $1.00 cy, $0.50 mn.

From 2nd International Thorium Fuel Cycle Symposium, Gatlinburg, Tenn.

Preliminary designs for head-end reprocessing facilities integral with an HTGR power plant have been prepared. In all cases, a thorium-uranium oxide ash is produced which is suitable for further reprocessing in existing off-site reprocessing facilities (modified slightly for ash handling and thorium recovery and storage). The designs make maximum use of reactor auxiliary equipment, services, and personnel by sharing fuel handling equipment, hot service facilities for equipment maintenance, the decontamination system, the radioactive waste disposal system, and the reactor plant ventilation system and stack. The head-end reprocessing facilities are designed for remote maintenance with major equipment repairs made in the reactor hot service facility. The shape of the fuel element has been found to have only a slight effect on the process and equipment. (The study is based on fuel particles not bonded to each other or to the fuel element graphite.) Costs are being developed for spent fuel shipping, ash shipping, and on-site and off-site fuel reprocessing so that cost comparisons can be made for various fuel cycle alternatives. (auth)

**145** (ISO-SA-7) SOLVENT EXTRACTION RECOVERY OF AMERICIUM WITH DIBUTYL BUTYL PHOSPHONATE. Kingsley, R. S.; Hopkins, H. H. Jr. (Isochem Inc., Richland, Wash.). Mar. 17, 1966. Contract AT(45-1)-1851. 24p. (CONF-660320-16). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From American Chemical Society, 151st Meeting, Pittsburgh.

A solvent extraction process was developed to recover americium from the Hanford Plutonium Reclamation Facility's aqueous waste stream. The process is based on the single-stage batch extraction of americium with 30 vol % dibutyl butyl phosphonate-70 vol % $CCl_4$. Americium is then stripped from the organic phase with water. A steady-state recovery flow sheet, which gave 97% recovery, was demonstrated in the laboratory. A product containing $5 \times 10^4$ parts americium per $10^6$ parts impurities was obtained from a feed containing 200 parts americium per $10^6$ parts impurities. The process chemistry for the recovery flow sheet was studied in detail. Significant process variables that affect americium recovery are the extractant composition, equilibrium aqueous phase acidity, and the aqueous phase salting strength. An unexpected reversal in the order of salting agents was observed for americium extraction from the highly salted (4 to 6 M $NO_3^-$) Reclamation Facility's aqueous waste. Additional support was also found in these experiments for the formation of an aqueous phase americium hydrogen complex. (auth)

**146** (JUL-359-DE) DIE BEHANDLUNG UND ABLEITUNG RADIOAKTIVER ABWAESSER. EINE UEBERSICHT. (Treatment and Disposal of Radioactive Waste Water. A Review). Schulze-Rettmer, R. (Kernforschungsanlage, Juelich (West Germany)). Mar. 1966. 53p. Dep. mn.

A review is given of the treatment and disposal of radioactive waste water at a large number of reactor centers and other nuclear installations. Procedures used in the German Republic (Berlin, Garching, Geesthacht, Gundremmingen, Hoechst, Juelich, Kahl, and Karlsruhe), Canada (Chalk River), Denmark (Risö), France (Fontenay-aux-Roses, Grenoble, Marcoule, and Saclay), Great Britain (Aldermaston, Harwell, Windscale), Italy (Ispra), Netherlands (Petten), Austria (Seibersdorf), Sweden (Studsvik), Switzerland (Wurenlingen), and the United States (Argonne, Brookhaven, Dresden, Hanford, Knolls Atomic in New York, Oak Ridge, Pennsylvania, and Shippingport) are reported. (102 references). (J.S.R.)

**147** (MCW-1435) DETERMINATION OF FRACTION OF TRIBUTYL PHOSPHATE COMPLEXED BY URANIUM AND DETERMINATION OF TOTAL CONCENTRATION OF TRIBUTYL PHOSPHATE IN REFINERY SOLVENT. Christopherson, H. L. (Mallinckrodt Chemical Works, Weldon Spring, Mo. Uranium Div.). Aug. 1, 1966. Contract W-14-108-eng-8. 20p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The equilibrium distribution of uranyl nitrate between water and 26 volume percent TBP (tributyl phosphate) in hexane has been experimentally determined and plotted as fraction of TBP complexed by uranyl nitrate, over the range 0.5 to 1, vs density of the aqueous phase. From a comparison of data on the equilibrium distributions of uranyl nitrate and nitric acid between water and 30 volume percent TBP in Gulf BT, an estimate and curve was made of the equilibrium distribution of uranyl nitrate between 26 volume percent TBP in hexane and the aqueous phase resulting from shaking 1 volume of stock uranyl nitrate solution with 10 volumes of 26 volume percent TBP in hexane solvent containing various amounts of uranyl nitrate and an amount of nitric acid that is in equilibrium with 1M excess $HNO_3$ in the aqueous uranyl nitrate feed solution with which the solvent had been contacted. Equations were derived for calculating the fraction of TBP complexed by uranyl nitrate from this curve and from density measurements on the aqueous phase before and after shaking a plant solvent with $^1/_{10}$ its volume of a stock uranyl nitrate solution. The assumptions made in these derivations are discussed, and the proportionality constants introduced are evaluated from data in the literature and additional experiments. Equations were also derived for calculating the initial concentration of TBP in the solvent from the above data, and an additional aqueous-phase specific-gravity measurement was taken after shaking the equilibrated solvent with $^1/_{10}$ its volume of distilled water. An estimate of the order of magnitude of the accuracy of determining the fraction of TBP not complexed by uranyl nitrate is the larger of ±10% relative or 0.001 absolute at the 95% confidence level. The precision of this method is estimated to be about 3 to 5 times better than the accuracy. The accuracy of determining the concentration of TBP is estimated to be roughly ±2% relative and the precision about ±1% relative at the 95% confidence level. (auth)

**148** (STI-PUB-116) PRACTICES IN THE TREATMENT OF LOW- AND INTERMEDIATE-LEVEL RADIOACTIVE WASTES. Proceedings Series. Proceedings of a Symposium held in Vienna, 6-10 December 1965. (International Atomic Energy Agency, Vienna (Austria)). June 1966. 956p. (CONF-651202). IAEA: $19.00; S 399,-; £5.14.0; F Fr 76,-; DM 66,50.

Separate abstracts were prepared for 15 of the 53 included papers. The remaining 38 papers appeared previously in NSA. For abstracts of these papers see CONF-651202 in the report number index. (R.C.K.)

*For abstracts of individual papers see: 257-271.*

**149** PRODUCTION OF SHORT-LIVED ISOTOPES WITH THE AID OF ISOTOPE GENERATOR. Toerko, Janos. Magyar Kem. Lapja, 21: 459-64(Sept. 1966). (In Hungarian).

Generators for the production of short-lived isotopes are briefly discussed. A literature review is given regarding the construction and operation of generators within the scope of which the systems $^{90}Sr-^{90}Y$, $^{99}Mo-^{99m}Tc$, $^{87}Y-^{87m}Sr$, $^{132}Te-^{132}I$, $^{68}Ge-^{68}Ga$ and $^{115}Cd-^{115m}In$ are summarized. Besides the principal mathematical relations suitable for the calculation of activities produced the most important papers dealing with generators are discussed. (auth)

**150** REVERSED-PHASE PARTITION CHROMATOGRAPHY OF THE RARE EARTHS USING METHYLENEBIS [DI(2-ETHYLHEXYL)-PHOSPHINE OXIDE] AS THE STATIONARY PHASE. O'Laughlin, Jerome W.; Ferguson, Jerry W.; Richard, John J.; Banks, Charles V. (Ames Lab., Ames, Iowa). Contract W-7405-eng-42. J. Chromatog., 24: 376-82(Oct. 1966). (IS-1326).

$R_F$ values are given for the rare earth nitrates, chlorides, and perchlorates on paper impregnated with methylenebis[di(2-ethylhexyl)phosphine oxide] (MEHDPO). The much lower $1/R_F - 1$ values for the rare earth perchlorates on MEHDPO-treated paper than on paper treated with the analogous extractant without the ethyl groups in the 2-position (MHDPO) are rationalized on the basis of steric factors. The greater separation factors for the rare earths observed in the nitric acid system with MEHDPO are explained on the same basis. (auth)

**151** REVERSED-PHASE PARTITION CHROMATOGRAPHY ON PAPER TREATED WITH DI-(2-ETHYLHEXYL) ORTHOPHOSPHORIC ACID: A SYSTEMATIC STUDY OF 67 CATIONS IN HYDROCHLORIC ACID. Cerrai, E.; Ghersini, G. (CISE, Milan). J. Chromatog., 24: 383-401(Oct. 1966).

The behavior of 67 cations in reversed-phase partition chromatography on paper treated with di-(2-ethylhexyl) orthophosphoric acid was investigated. Hydrochloric acid was used as the eluent in a concentration range of 10M to $1 \cdot 10^{-4}$M. For 48 cations the quantity $(1/R_F - 1)$ was related to the hydrogen ions activity in the mobile phase and to the effective HDEHP concentration on the paper. The chromatographic behavior was correlated to that in analogous liquid-liquid extraction systems. Particular attention was devoted to U(VI) and to the rare earth metals. (auth)

**152** THIN-LAYER CHROMATOGRAPHY ON SUPPORTS IMPREGNATED WITH NEUTRAL ORGANOPHOSPHORUS COMPOUNDS. Brinkman, U. A. Th.; Veltkamp, H. (Free Univ., Amsterdam). J. Chromatog., 24: 489-91(Oct. 1966).

A study of thin-layer chromatography of 25 ions on silica gel impregnated with tri-n-butylphosphate (TPB) and tri-n-octylphosphine oxide (TOPO) was made. Results showed good over-all correspondence with literature data, except for Ti(IV), Zr(IV), and Hf(IV), which gave lower $R_F$ values. For most ions a good agreement existed between thin-layer data concerning TBP and TOPO, and liquid anion-exchangers; however with Zr and Hf in the case of TOPO and with Sc and Th for both organophosphorus compounds, significant discrepancies occurred. In all these cases very good agreement existed between paper and thin-layer data of the organophosphorus compounds. The usefulness of TBP and TOPO in chromatography is discussed. (D.H.M.)

**153** THE PRODUCTION OF HIGH-PURITY URANIUM AT A SOUTH AFRICAN GOLD MINE. Faure, A. J. S. Afr. Inst. Mining Met., 66: 319-41(1966).

The chemistry of the Bufflex solvent-extraction process is described. Uranium is extracted by a tertiary amine solvent, from which the impurities are removed by means of dilute ammonia, and the uranium is stripped by an ammonium sulfate solution. In the pilot plant, these processes are carried out in mixer-settlers. Details of pumps, flow controllers, and materials of construction are given. The operations of the extraction, scrub, strip, precipitation and thickening, and regeneration sections are described. Comparative tests on the elution of ion-exchange resins with 10% sulfuric acid, and with nitrate, are described. The results of resin analyses and plant tests are given. A breakdown of the costs of reagents in the Bufflex process, compared with the conventional process, is given. It was concluded that a solvent-extraction process treating the sulfuric acid eluant from ion-exchange columns is technically feasible. As to the resin itself, elution with 10% sulfuric acid is satisfactory. There is more polythionate build-up than with nitrate elution, and the capacity of the resin is slightly lower, but the difference is small. The operating cost of the Bufflex process is cheaper by at least 5 cents per pound of $U_3O_8$ produced. The product satisfies the most stringent specifications for nuclear-grade uranium, except as regards cobalt, molybdenum, silicon, and hafnium. (Atom Dokumentation)

**154** SEPARATION OF RARE-EARTH METALS BY ION EXCHANGE. III. REVERSAL IN THE SEQUENCE OF ELUTION OF EUROPIUM AND YTTRIUM FROM DOWEX 50W-X8 WITH AMMONIUM ACETATE. Mikler,

J. (Univ., Vienna). Monatsh. Chem., 96: 1007-13(1965). (In German).

When ammonium acetate-acetic acid (47 : 3), 0.73 M in acetate, is used as eluent, Eu and Y are eluted together. With lower concentration, but constant composition of the eluent, Eu is eluted before Y, and with higher concentration the situation is reversed. Resins with different degrees of crosslinkage used under otherwise identical conditions also exhibit this reversal of the elution sequence. (Anal. Abstr.)

**155** ISOLATION OF SMALL AMOUNTS OF ZIRCONIUM FROM NITRIC ACID SOLUTIONS ON ACTIVATED CARBON MODIFIED BY PHENYL ARSONIC ACID. Kyrs, M.; Pistek, P.; Selucky, P. (Inst. for Nuclear Research, Czechoslovak Academy of Sciences, Rez). Collect. Czech. Chem. Commun., 31: 2689-94(July 1966). (In German).

It was established that by means of activated carbon modified with benzenearsonic acid a very efficient absorbent can be prepared. The sorption efficiency greatly exceeds the surface bonding of the Zr in the application of the usual sorbents. In addition to Zr, Nb, and nitrosy ruthenium were bound to a significant degree, but Cs, Sr, Y, and Ce were not sorbed. The sorption of Zr on Teflon in the presence of benzenearsonic acid under static conditions permits the separation of carrier-free $^{95}Zr$ and $^{95}Nb$ from $^{106}Ru$, $^{90}Y$, $^{144}Ce$, $^{90}Sr$, and $^{137}Cs$. (tr-auth)

**156** NOTE ON A PAPER "ISOTOPIC ENRICHMENT OF $^{14}C$ BY CHROMATOGRAPHY ON THIN LAYERS." Moravek, J.; Leseticky, L. (Inst. of Organic Chemistry and Biochemistry, Prague). Int. J. Appl. Radiat. Isotop., 17: 607(Oct. 1966).

Viswanathan reported in the paper the chromatography of carbon-14-labeled sodium formate in a mixture of ethanol, ammonia, and water. In a reproduction of the experiment, the radioactive zone was found to contain carbon-14-labeled ammonium formate the specific activity of which was the same as that of the sodium formate before chromatography. There was no isotopic enrichment. (M.C.G.)

**157** THE ENRICHMENT OF $^{37}Cl$ BY COUNTERCURRENT ELECTROLYSIS OF FUSED $PbCl_2$. Selecki, Anatol; Czelej, Marek (Inst. of Nuclear Research, Warsaw). Nukleonika, 11: 437-40(1966). (In Polish).

The enrichment of $^{37}Cl$ was realized by countercurrent electromigration in molten $PbCl_2$. The current density was 5 A/cm$^2$. After 73 hr the concentration of $^{37}Cl$ obtained on the boundary, $PbCl_2$–Pb (K), was 30.9%. It was calculated that in this case simple enrichment factor was 0.002. (auth)

**158** THE PROCESSING OF U ORES IN FRANCE. Leger, J. E. (Etablissements Kuhlmann, Brignoud, France); Renaud, J. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 60, 10-15(July-Aug. 1966). (In French).

The techniques used in France for processing U ores are briefly summarized with emphasis on the concentration technique. These include mechanical conditioning, dissolution of the U and washing of the gangue, and U recovery from solutions. Possible new techniques for the chemical treatment of U ores are indicated. (J.S.R.)

**159** MESITYL OXIDE AS AN EXTRACTING AGENT. Khopkar, Shripad M. (Indian Inst. of Tech., Bombay). J. Sci. Ind. Res. (India), 24: 242-3(1965).

The literature up to early 1964 on the use of mesityl oxide is reviewed, with emphasis on the extraction of Th and U from aqueous solutions. The ability of this compound to form complexes with Pt, Pd, and Os is briefly discussed, and some of its other uses are mentioned. (27 references.) (Anal. Abstr.)

**160** TREATMENT OF RADIOACTIVE LIQUID EFFLUENTS AT THE CENTRO STUDI NUCLEARI OF CASACCIA. Branca, G. Acqua Ind., No. 33, 19-34(1964). (In Italian). (RT/PROT(65)-9).

The liquid waste processing plant at Casaccia is described. The possibility of release of the treated effluents to the environment outside of the center is discussed. The quantity and nature of the waste of the center and the methods used for its collection are described. The processing plant itself is described and the materials used in the plant are indicated. (J.S.R.)

**161** MERCURY MASS-DIFFUSION COLUMN FOR ISOTOPE SEPARATION. Nikolaev, B. I.; Neshchimenko, Yu. P.; Sulaberidze, G. A.; Lalayan, V. M. At. Energ. (USSR), 21: 62(July 1966). (In Russian).

Calculations on the mass diffusion process concerning the molecular weight of the materials in the gas phase and the molecular weights of the isotopes to be separated indicated that if parasitic effects in the columns, such as the solubility of the gas mixture in the condensate layer, are neglected, it is possible to achieve a very high degree of separation by using organic liquids. However, the previously used liquids, such as xylene, nitrobenzene, tetrachloroethylene, etc., are good solvents of the gases to be separated; on the other hand, the molecular weight of water is too low. Experiments were therefore carried out with metallic mercury as the liquid because it possesses a sufficiently high molecular weight together with the desired vapor pressure and the low solubility for the gases in question. A 1 m long column was used for separating neon isotopes, making sure that no metals forming amalgams were used for the structural portions. The separation tests, carried out with a double layer diaphragm and an operational pressure of 20 mm of Hg, yielded a separation factor of 17. (TTT)

**162** STUDIES OF CRITICALITY OF PILOT PLANT FACILITY FOR PROCESSING IRRADIATED MTR-TYPE FUELS. Pereira Sanchez, G.; Uriarte Hueda, A. (Junta de Energia Nuclear, Madrid). 30p. (In Spanish). (CONF-651103-28; SM-70/26). ORAU.

From IAEA Symposium on Criticality Control of Fissile Materials, Stockholm.

As a preliminary step in the design of a pilot plant for the processing of irradiated MTR-type fuel elements, criticality studies were made on each component of the installation. The interactions between the units are also considered. The calculations were based on the "solid angle" concept and the "albedo" concept. The effective multiplication factor was calculated for each unit, and the operational conditions of the installation in the event of a nuclear incident were fixed. (J.S.R.)

**163** DETERMINATION OF ION EXCHANGE EQUILIBRIUM DATA BY LIQUID SCINTILLATION COUNTING. Meyer, Walter (Kansas State Univ., Manhattan). 30p. (CONF-660606-28). ORAU. Gmelin, AED-CONF-66-203-33.

From American Nuclear Society Meeting, Denver, Colo.

Liquid scintillation counting technique has been applied to the determination of ion exchange and electrolyte sorption data for ion exchange systems. The method was developed for the system $H^+$, $Cs^+$, $Sr^{2+}$, and $Ce^{3+}$ using the appropriate isotopes of the cations and a batch type equilibration with the resin. Since the cations were in aqueous solution and did not mix with the toluene solvent of the scintillator, the samples were counted as emulsions. The experimental techniques and the treatment of data are discussed in detail. (B.L.M.)

**164** PILOT-PLANT AND COMMERCIAL-SCALE DEVELOPMENT OF PROCESSES FOR REMOVAL OF RADIONUCLIDES FROM MILK. Walter, H. E. (Dept. of Agriculture, Washington, D. C.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-75/6, 16p. (CONF-660711-5). ORAU.

From Seminar on the Use of Radioisotopes and Radiation in Dairy Science and Technology, Vienna.

Laboratory procedures for removing radionuclides from milk were developed on a pilot-plant scale using the fixed-bed ion-exchange process. The operational steps included: acidifying the cold whole milk with citric acid to pH 5.3; controlling the milk flow-rate through the previously regenerated resin column; neutralizing the milk with potas-

sium hydroxide to pH 6.7; pasteurizing, homogenizing, and deodorizing the milk, rinsing and cleaning the resin and regenerating the resin. A regenerant solution containing selected quantities of calcium, sodium, potassium, and magnesium salts removes the radiostrontium from the resin while regenerating it during the same operation. Radiostrontium removal averaged 91%, varying from 75 to 98%, depending on flow rates and pH. Barium-140 removal was approximately 85% and cesium-137 50%. Nutritional and chemical studies indicated only slight changes in composition, other than the increase in potassium and citrate. A dual system, using anion resin, removed 93% of iodine-131 from milk before the removal of 90% of strontium-90 with the cation resin. Flavor scores for 7-day refrigerated milk samples, using the American Dairy Science Association scoring system, were 36.7 for the control, 36.4 for anion treatment only, and 36.0 for combined anion-cation treatment. Commercial-scale adaptation of the automated pilot-plant process to 100,000 pounds of milk in eight hours, was accomplished under a contract. With 920,000 pounds of milk, averaging 34.2 pC/liter of radiostrontium, removal averaged 91.7%. Whole milk scores averaged 37.2 after processing, a decrease of 0.6 from the untreated sample. (auth)

**165** REMOVAL OF RADIOACTIVE STRONTIUM FROM MILK WITH COLUMNS OF $Ca_3(PO_4)_2$. Stoutjesdijk, J. F. (Association EURATOM-ITAL, Wageningen, Netherlands). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-75/28, 20p. (CONF-660711-3). ORAU.

From Seminar on the Use of Radioisotopes and Radiation in Dairy Science and Technology, Vienna.

Stirring milk with 8% of $Ca_3(PO_4)_2$ for 10 min resulted in a removal of about 60% of in vitro added Sr-85, 40% of the Ca and 16% of the milk-proteins. The taste of the treated milk was bad. A second stirring of the milk with Ca-phosphate gave a nearly quantitative removal of Sr-85. Addition of stable Sr was unfavorable. A treatment in columns of Ca-phosphate could remove about 98% of the Sr-85 with a loss of only 5% of the milk-protein. However, 50% of the Ca was also fixed to the column and the taste of the milk was bad. A decrease of the pH of the milk to 5.4 resulted in a more efficient removal of Sr-85, but also of Ca. The conclusion is that Ca-phosphate, used in the described manner, does not seem to be an alternative for organic ion-exchange resins for the removal of radioactive Sr from milk. (auth)

**166** PROCESSES FOR THE DISSOLUTION OF URANIUM IN NITRIC ACID. Rateau, Arthur (to Commissariat a l'Energie Atomique). Canadian Patent 738,910. July 19, 1966. Filed June 6, 1962.

An improved method of effecting the solution of uranium metal in nitric acid solution consists of introducing uranyl ions and maintaining a constant, calculated concentration of these ions. The construction of the apparatus is described. Corrosion is kept to a minimum because high temperatures or pressures are not required. (F.S.A.)

**167** SEPARATION OF URANIUM AND PLUTONIUM VALUES. Knighton, James B.; Steunenberg, Robert K. (to U. S. Atomic Energy Commission). U. S. Patent 3,282,681. Nov. 1, 1966.

A process for the separation of plutonium values from uranium values is given. The plutonium and uranium values are dissolved in a molten alloy of magnesium, in which uranium is present in a metallic phase, and the alloy contacted with a molten salt containing magnesium chloride to oxidize the plutonium to plutonium chloride, which dissolves in the salt. The salt is contacted with a molten zinc alloy containing 2 to 10 wt % magnesium to reduce the plutonium chloride to plutonium, which precipitates from the molten zinc alloy as a plutonium–zinc intermetallic compound. (AEC)

**168** PROCESS FOR SEPARATING STRONTIUM VALUES FROM RARE EARTH METAL VALUES. Van Tuyl, Harold H. (to U. S. Atomic Energy Commission). U. S. Patent 3,287,084. Nov. 22, 1966.

A process is described for separating strontium values from rare earth metal values in a solution having a pH between 2 and 2.5. A water-soluble compound containing tartrate anions and hydrogen peroxide is added to the solution. Ethylene glycol is added when the solution is radioactive and lead sulfate is precipitated from the solution whereby the strontium values are carried on the lead sulfate. Finally, the precipitate is separated from the aqueous solution. (AEC)

**169** SEPARATION OF URANIUM FROM NOBLE AND REFRACTORY METALS. Knighton, James B.; Steunenberg, Robert K. (to U. S. Atomic Energy Commission). U. S. Patent 3,284,190. Nov. 8, 1966.

A process for the separation of uranium values from refractory metals and noble metals is described. The values are dissolved in a molten alloy of copper containing 4 to 8 percent magnesium. The alloy is contacted with a molten salt containing an alkali metal chloride or an alkaline earth metal chloride to oxidize the uranium to uranium chloride which dissolves in the salt. The salt is contacted with a molten magnesium alloy to reduce the uranium chloride to uranium which precipitates in the molten magnesium alloy. (AEC)

# EARTH SCIENCES

## Geology

*Refer also to abstracts 98 and 194.*

**170** (SC-RR-66-547) SHOCK COMPRESSION OF POROUS MAGNETITE. Bass, Robert C. (Sandia Corp., Albuquerque, N. Mex.). Oct. 1966. Contract AT(29-1)-789. 10p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Shock compression experiments were conducted on porous magnetite ($Fe_3O_4$). Sample density of 2.91 gm/cm$^3$ was maintained. Results are compared to a synthesized Hugoniot for solid magnetite. Values are estimated for the Grüneisen parameter and temperature along the Hugoniot. (auth)

**171** GAMMA-SPECTROMETRIC STUDY OF MONT-BLANC GRANITE SAMPLES. Rybach, Ladislaus (Eidgenoessische Technische Hochschule, Zurich); von Raumer, Juergen; Adams, John A. S. Pure Appl. Geophys., 63: 153-60(196č/I).

Gamma spectra of granite samples were measured by standard laboratory multi-channel spectrometry. The weighted least squares method was applied to the digital output data in order to determine the concentrations of $^{238}U$, $^{232}Th$ and $^{40}K$ present. Uranium and Th increase towards the rim of the massif (from 4 ppm U and 20 ppm Th in the coarse-grained central facies to 23 ppm U and 42 ppm Th in the fine-grained rim variety), whereas K remains fairly constant at ~3.85%. (auth)

**172** MASS SPECTROMETER SYSTEMS FOR THE ISOTOPE GEOCHEMISTRY. PRECISION MEASUREMENT OF THE ISOTOPE RATIO OF VOLATILE ELEMENTS. Sakai, Hitoshi (Okayama Univ., Japan). Shitsuryo Bunseki, 14: 72-7(June 1966).

A mass spectrometer system for precise comparison of the isotopic ratio of sulfur, carbon, and oxygen is described. The results of $^{34}S/^{32}S$ ratio measurements indicate the reproducibility is better than ±0.2 per mil in terms of $\delta\ ^{34}S$ scale. $\delta\ ^{34}S$ troilite of a standard sulfur of the Canadian group was found to be +11.2 per mil in comparison with +10.8 per mil previously given. (NSA of Japan)

**173** VARIATION OF SULFUR CONTENT AND COMPOSITION OF PETROLEUM AND ASPHALT OF BASHKIRA PALEOZOIC DEPOSITS WITH VARIATIONS IN THEIR NATURAL RADIOACTIVITY. Zufarova, N. A. Khim. Seraorgan. Soedin., Soderzhashch. v Neft. i Nefteprod., Akad. Nauk SSSR, Bashkirsk, Filial, 7: 223-6(1964). (In Russian).

About 100 samples of oil were counted for radioactivity on an end-window counter. On the average the radioactivity varied from 100 to 180 cpm/g for sulfur contents up to 1.5% in the oil. The count was 200 to 260 cpm/g for a sulfur content of 2 to 3%, and with a count of 260 to 380 cpm/g, the sulfur content was >3%. The sulfur content increased with increasing radioactivity. The same trend was observed in organic bitumens which showed radioactivities of 500 to 2000 cpm/g, while the average sulfur content varied from 3 to 5%. (TTT)

**174** CONSIDERATIONS ON $^{14}C$-MIXED SAMPLE DATINGS. Geyh, Mebus A. ($^{14}C$-Labor, Niedersaechischer Landesamt fuer Bodenforschung, Hanover). Z. Geophys., 32: 154-6(1966). (In German).

Estimations of error for dating of mixed $^{14}C$ samples are discussed. Results show that errors in age are smallest if the sample under investigation is mixed with "infinitely" old material. The use of only slightly active $^{14}C$ material is recommended only when very recent samples must be admixed with a small amount of material. A special error function Q is graphically illustrated for a proportional counter with a total pressure of 150 torr in the mixture container, with pressure readability ±1 torr, and a sampling time of 2000 min. It was found that the standard net counting rate of the counter was about 10 cpm. The optimum mixed sample net counting rate depends on the sample net counting rate, not the net rate of a sample with $^{14}C$ age = 0 nor the null effect of the detector under standard operating conditions. (BBB)

**175** ISOTOPIC INVESTIGATIONS FOR DETERMINATION OF THE ORIGIN OF ROMAN LEAD TUBES AND LEAD BARS. Groegler, N.; Geiss, J.; Gruenenfelder, M.; Houtermans, F. G. (Univ., Bern. Eidgenoessische Technische Hochschule, Zurich). Z. Naturforsch., 21a: 1167-72(July 1966). (In German).

The isotopic composition of lead in archaeological objects can be used to trace the origin of this lead. The lead isotopic composition is given of 10 Roman lead pipes and ingots, found on the European continent. In spite of the limited number of samples and the restricted area, significant differences in the isotopic composition are found exceeding by far the experimental limits of error. Thus, it is shown that the isotopic composition of lead is indeed a sensitive tracer for the origin of historical lead objects. Results are compared with the isotopic compositions of European lead ores. For some examples the possibilities and the limitations of the method are discussed. (auth)

**176** POTASSIUM-ARGON AGES OF SOME WESTERN TERTIARY FLORAS. Axelrod, Daniel I. (Univ. of California, Los Angeles). Amer. J. Sci., 264: 497-506 (Summer 1966).

Potassium-40/argon-40 values were determined for some flora samples from California, Washington, Idaho, and Nevada. The K/Ar dates indicate an Eocene age for 6 Tertiary floras that represent vegetation zones as diverse as mixed deciduous hardwood forest, conifer-hardwood forest, and subalpine forest. Paleobotanical age criteria suggest these upland floras are much younger, confirming evidence that indicates Eocene forests that existed in regions of temperate climate had the aspect of Neogene floras. Certain K/Ar dates previously assigned to Tertiary floras disagree with paleobotanical evidence for their age. Some of the discrepancies reflect the problem of altitude and the floras of younger aspect that lived there, but others appear to be due to dating rocks not associated with the floras, to contaminated samples, and to other reasons. From the evidence reviewed it is seen that the dates assigned by paleobotanists to 88% of the 40 dated floras examined are in close agreement with the results of K/Ar dating: 35 of the 40 floras have been dated within 3 million yr of K/Ar ages and 30 of them are within 1 to 2 million yr. (BBB)

**177** METHOD FOR RAPID RADIOCARBON MEASUREMENTS. Zavelskii, F. S.; Alekseev, V. A. (Geological Inst., Moscow). Prib. Tekh. Eksp., No. 2, 73-5 (Mar.-Apr. 1966). (In Russian).

A method is suggested for rapid radiocarbon measurements by using an additional computing channel which controls the background during measuring processes. At standard conditions the maximum geological age measurements with the device are limited to ~40 to 50 thousand years. (R.V.J.)

**178** DISTRIBUTION OF FALLOUT RADIOACTIVITY IN A WATER SUPPLY RESERVOIR. Bernhardt, Heinz (Wahnbachtalsperrenverband Siegburg, Ger.). Wasserwirtschaft. 53: 450-2(1963). (In German).

Stored waters and lakes represent an important area which may be seriously contaminated from radioactive fallout. The atomic test series of 1961/62 resulted in radioactivity increases in waters of the Wahnbach valley reservoir. Studies of the increase in radioactivity concentrations in this reservoir were made on the region of the surface and at two depths. The results of these studies were related to the time of yr. It was found that the sp act.

during the periods of complete circulation were equally high at all water depths and were close to the radioactivity concentration at the surface. During the summer warming period it decreased at greater water depths as a result of temperature layering, although the activity on the surface increased. Thus, it appeared that layered drinking water sources that circulate relatively little contained less radioactivity than water located at great depths. The fact that during the very cool summer of 1962 there was only a limited amount of temperature layering, which still resulted in a period of considerable stagnation when the radioactivity concentration at the lower depths was lowered as compared to the surface water, emphasizes the importance of this phenomenon for removal of drinking water from reservoirs with heavy surface contamination. (BBB)

**179** THE OCCURRENCE OF $^{14}C$ AND TRITIUM THROUGHOUT SCANDINAVIA, WITH APPLICATIONS IN SOIL SCIENCE AND HYDROLOGY. Oden, Svante (Institutionen foer Markiaera, Uppsala). Grundforbattring, 17: 122-42(1964). (In Swedish).

As a consequence of the atomic bomb tests during the last decade, an artificial labeling by $^{14}C$ and tritium has occurred in all natural reservoirs. At the International Meteorological Institute in Stockholm, efforts have been made to follow this labeling in time and space and to utilize it in computations of reservoir characteristics such as turnover time, exchange properties, and damping and mass characteristics. In addition to a global network for atmospheric tritium assays, a fairly dense network has been set up over Scandinavia, including the monitoring of both atmospheric tritium (precipitation and water vapor) and surface and ground water tritium from different reservoirs. These data are discussed and correlated with the long-term tritium variations as shown by other stations in Northern Europe. The natural, time-variable labeling of tritium is useful in studies of ground water bodies and open aquifers as well as in soil physics and plant ecology research. Applications in these fields are given and solutions to some problems, which are difficult to obtain by other methods, are discussed. The most useful investigation technique in geophysical and geochemical studies attempts to combine chemical and isotopic measurements in all reservoirs taking part in the circulation of matter. The described network operates according to this principle. (BBB)

**180** STUDIES OF DECONTAMINATION PROCEDURES FOR CATCHMENT BASIN WATERS BY MEANS OF RAPID FILTRATION PLANTS. Bernhardt, H.; Hartmann, H.; Baumgaertel, F. (Technische Hochschule, Brunswick). Vom Wasser, 30: 104-26(1963). (In German).

Maximum permissible activity values of catchment basin waters contaminated by fallout can be calculated. To be suitable for drinking purposes, the degree of decontamination should be at least 95%. Flocculation with Al or Fe salts, Na carbonate softening, or phosphate precipitation are the decontamination procedures most suitable for open rapid filtration plants. Using normal amounts of Al or Fe compounds in flocculation procedures, the degree of decontamination reached for $^{89}Sr$ is less than 30%, but for $^{144}Ce$ it is 99%. Increasing the amount of flocculent increases the degree of decontamination only slightly. The degree of decontamination reached with flocculation procedures increases with increasing pH. For this reason, Fe salts, which floc in alkaline ranges, are more efficient than Al compounds for removal of radionuclides. The degree of decontamination for $^{89}Sr$ can be increased to 55% by phosphate precipitation. High pH values also increase this decontamination effect. A decontamination effect ~90% as a max can be achieved by this procedure. The degree of decontamination of ~95% can be attained in water containing $^{144}Ce$ by Fe hydroxide precipitation but it is not as effective for radioactive Sr. Flocculation using additions of as much as 60 mg/l of a flocculation material has been tested at a rapid filtration plant. (BBB)

**181** STRONTIUM CONTENT OF LIMESTONES OF SOUTHERN GERMANY. Bausch, W. M. (Univ., Erlangen-Nuernberg, Ger.). Geol. Rundschau, 55: 86-96(1966). (In German).

Strontium content was determined at various levels in borings taken from limestones in Bavaria, France, and Switzerland. Curves of strontium contents from profiles of Upper Jurassic limestones in Southern Germany were remarkably similar over great distances. The reason for this is that the strontium is mostly adsorbed by the clay minerals. It is assumed that this strontium was set free during the early transformation of aragonite to calcite. On the basis of this hypothesis and a further extrapolation an attempt is made to outline the principles of the distribution of strontium in sediments. Phase diagrams are provided to show the distribution of strontium in sediments. (BBB)

**182** THE ISOTOPIC COMPOSITION OF NATURAL WATERS WITH SPECIAL REFERENCE TO THE GREENLAND ICE CAP. Dansgaard, W. (Oersted Inst., Copenhagen). Medd. Groenland, 165: No. 2, 120p(1961).

Techniques and results of $^{2}H$ and $^{18}O$ measurements in arctic waters and icebergs are reported. Formulas were evaluated for the isotopic fractionation of water in isothermal evaporation and condensation processes. Formulas for non-isothermal processes were evaluated. The ratio between the absolute enrichments of the heavy components, HDO and $H_2{}^{18}O$, is shown to be ~1.5. Whereas ocean waters have rather uniform isotopic composition, the $^{18}O$ content of fresh waters decreases with the temperature at the site of formation. A linear correlation was found between the annual means of the air temperature and the $^{18}O$ content of the precipitation at coastal stations at sea level and in temperate or arctic climate. Another linear correlation was found mainly between the same parameters at Greenland ice cap stations with high altitudes. The isotopic latitude effect along the West Greenland coast is −0.93 ppM/°C latitude. The seasonal isotopic variation of the precipitation corresponds roughly to the seasonal variation in air temperature. The isotopic variations during rainy periods are discussed. Isotopic stratification in $^{2}H$ and $^{18}O$ was demonstrated in an iceberg and a glacier. A detailed description is given of a method for determining the sites of formation on the ice cap for icebergs. If the $^{18}O$ contents of the 11 icebergs are corrected for latitude effect, they show a linear correlation with the ages which suggests the possibility of an iceberg dating method on the basis of $^{18}O$ measurements. (BBB)

**183** EXOELECTRON-EMISSION PHENOMENA AND GEOLOGICAL APPLICATIONS. Lewis, D. R. (Shell Development Co., Houston, Tex.). Geol. Soc. Amer. Bull., 77: 761-70(July 1966).

An apparatus designed to detect exoelectron emission is described and illustrated. It was developed to examine rocks that have been exposed to ionizing radiation and heated, which then emit from their surfaces electrons which can be measured with a $\beta$ counter. This emission of exoelectrons can be interpreted in terms of trapping energies associated with the defects produced by mechanical strain, trace element impurities, or lattice imperfections. The exoelectrons are emitted over discrete temperature intervals determined by the nature of the rock surface and the defect population in the surface. The graph of the amount of exoelectron emission vs temperature is known as an exoelectron glow curve. These curves can be compared with thermoluminescence glow curves and other measurements which characterize the number and energies of defects in the surface and the bulk rock. The defect population may therefore be related to such important properties as the mechanical strength and the influence of the tectonic and thermal history of the rock. Irradiation of the specimens was carried out with 80-kv x rays or $^{60}Co$ $\gamma$ rays. (BBB)

**184** ISOTOPIC AGE OF TIN GRANITES IN RONDONIA, N. W. BRAZIL. Priem, H. N. A.; Boelrijk, N. A. I. M.; Hebeda, E. H.; Verschure, R. H.; Bon, E. H.

(Laboratorium voor Isotopen-Geologie, Amsterdam). Geol. Mijnbouw, 45: 191-2(June 1966).

The $^{87}Sr/^{86}Sr$ and Rb and Sr contents were measured for Rb–Sr age determinations of rock samples and on concentrates of biotite. The biotite was also dated according to the $^{40}K$–Ar method. The isotopic Rb–Sr and K–Ar age determinations establish a late-Precambrian age of 940 ± 20 million yr for the emplacement of the tin granites in Rondonia. Geologic field studies point to an anorogenic or post-tectonic intrusion of the granites. It is not yet possible to fit the age of emplacement of the Rondonian tin granites into the Precambrian stratigraphy of the northwestern parts of the Brazilian Shield. The only area of the Brazilian Shield of which isotopic ages have been studied in detail is the Quadrilatero Ferrifero around Belo Horizonte, Minas Gerais. Three periods of granite emplacement were established in that area, viz., about 2400, 1350 and 450–550 million yr ago, none of which can be related to the age of the Rondonian tin granites. However, ages of roughly 1000 million yr have been reported from Minas Gerais as well. These ages were measured according to the U–Pb and Th–Pb methods on minerals (mainly monazite) from cassiterite-bearing pegmatites. If a comparison is made with the sequence of orogenies and granite emplacements in the Precambrian of North America, the age of the tin granites in Rondonia can be related to the Grenville orogeny, 950 ± 60 million yr ago. (BBB)

**185** MEASUREMENT OF DENSITY AND MOISTURE USING RADIONUCLIDES. Kosmowski, A. (Frieseke and Hoepfner, Erlangen, Ger.). Instrum. Pract., 20: 669-72(Aug. 1966).

The use of radionuclides for gaging and controlling density and moisture is reviewed. When different kinds of liquids, e.g., raw oil, fuel oil, or gasoline are transported in pipelines, it is possible using radionuclides to measure continuously the density variation and thus to establish changes in the liquids being transported. The measurement is based on the principle of absorption of nuclear radiation in liquids, the degree of absorption depending on the density. The radiation from the radioactive source penetrates diametrically through the pipe and, after having been partly absorbed, reaches the measuring chamber. The electrical impulses from ionization are fed into an amplifier and are indicated on a calibrated instrument. Sources of $^{60}Co$ and $^{137}Cs$ with half-life periods of 5.2 and 30 yr respectively are suitable. It is possible to make density measurements on pipelines of 200 to 1000 mm dia. This measuring process has the advantage that even corrosive liquids can be measured without sampling. Coarse suspensions can also be measured without difficulty. The uncertainty of measurement is 2% of the measuring range and not less than 0.001 g/cm$^2$. Another important use of density measurement with nuclear radiation is the determination of solid content and solid handling rate of suction dredges. During manufacture or preparation of bulk materials such as foundry molding sand, sinter ore mixture, constituents for concrete, glass and ceramics it is important to control the moisture content. The equipment used comprises a moisture primary element, an industrial ratemeter, and a source holder with an Am–Be neutron source having an activity of 100 mC. High speed neutrons emitted by the source are slowed down depending on the proportion of H in the material under test. Resulting thermal neutrons are proportional to the moisture content of the material under test. Elements which readily absorb the neutrons such as B, Cd, and certain rare earths should be eliminated from the material to be measured (interference above 1 ppM may occur). The content of coal and O should not vary greatly. If the measuring probe is uniformly surrounded by the material to be measured, there will be a linear relation between the measuring signal and the moisture. (BBB)

**186** THE COMPOSITION OF EXCESS ARGON IN SCHWARZWALD FLUORITES. Lippolt, H. J. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 1162-6(July 1966). (In German).

The argon and potassium contents of eight fluorite samples with microinclusions from the Schwarzwald, Germany, were measured by the isotope-dilution technique. The samples contain .5 to $5 \times 10^{-7}$ cc radiogenic Ar/g and there exists an approximate proportionality between the radiogenic and atmospheric argon component. In six samples the ratio Ar(rad)/Ar(total) at the time of mineral formation lies between .38 and .52 and probably represents the ratio in the mineral-forming brine. These numbers are compatible with the argon ratios found in natural gases from bedrocks. Elinson and Polykovskii claim argon contents in fluid inclusions of pegmatitic feldspar ten times higher than the radioactive decay of $^{40}K$ in the lattice would produce. Assuming this excess occurring frequently in pegmatitic feldspar and the pertinent $\epsilon_0$-values >0, there could be a considerable source of error for K–Ar determinations of such minerals. (auth)

## Meteorology

*Refer also to abstract 203.*

**187** RADIOACTIVITY OF THE AIR AT THE SERVICE OF METEOROLOGY AND ATMOSPHERIC PHYSICS. Blanc, Daniel; Fontan, Jacques (Faculte des Sciences, Toulouse). Nucleus (Paris), 7: 167-76(May–June 1966). (In French).

The origin of atmospheric radioactivity, both natural and artificial, is reviewed. The installations used for the instantaneous and continuous measurement of Rn and Tn are described. Techniques used in the measurement of atmospheric diffusion in the lower atmospheric levels are outlined. Methods used to determine air movements on an average scale, circulation of air masses on a large scale, exchanges across the tropopause, and cleaning of the troposphere are discussed in order to show how the results of these measurements may be used by the meteorologists and the atmospheric physicists. (J.S.R.)

**188** CONTENT OF $^{90}Sr$ AND $^{137}Cs$ IN RADIOACTIVE FALLOUT IN 1964. Csupka, S.; Petrasova, M.; Carach, J. (Regional Hygiene-Epidemiology Station, Bratislava). Cesk. Hyg., 10: No. 10, 615-17(1965). (In Czech).

Monthly levels of fallout for Western Slovakia in 1963 and 1964 are given (total $\beta$ activity and $^{90}Sr$ and $^{137}Cs$ activity) and compared with results for 1961 and 1962. Peak values for 1964 were noted in June for total activity (49.4 nC/m$^2$) and in April for $^{90}Sr$ and $^{137}Cs$ (3.27 and 2.61 nC/m$^2$). However, all three values were lower in 1964 compared with 1963. Average yearly values for 1963 and 1964 were 78.6 and 20.1 nC/m$^2$ for total $\beta$ activity, 1.74 and 1.41 for $^{90}Sr$, and 2.35 and 1.29 for $^{137}Cs$, giving respective 1964/1963 ratios of 0.25, 0.81, and 0.55. The higher ratio of $^{90}Sr$ and $^{137}Cs$ in the total $\beta$ activity indicates that the 1964 fallout is mainly of stratospheric origin. In 1963, $^{90}Sr$ activity accounted for only 2.2% of the total $\beta$ activity, compared with 7.0% in 1964. The corresponding ratios of $^{137}Cs$/total $\beta$ activity were 3.0% for 1963 and 6.4% for 1964. The cumulative yearly values of fallout for $^{90}Sr$ and $^{137}Cs$ were 20.88 and 28.23 nC/m$^2$ for 1963 and 16.86 and 15.46 for 1964. In the Bratislava area the total $\beta$ activity of fallout was not influenced subsequent to the Chinese nuclear test explosion on October 16, 1964. (BBB)

**189** IDENTIFICATION OF AcC IN THE ALPHA RADIOACTIVITY IN THE AIR. Caruso, E. (Univ., Milan, Laboratori CISE, Milan). Energ. Nucl. (Milan), 491-2(Sept. 1966).

The short-lived alpha radioactivity of the air over Segrate (Milano), Italy was analyzed using a gridded parallel plate ionization chamber with a gas filling of 90% Ar and 10% $CH_4$. The atmospheric aerosols were collected by effluvium deposition, and the measured $\alpha$ spectra for the samples are shown. By this method, the presence of AcC ($^{211}Bi$) was established and its concentration measured in air samples taken near uranium mineral deposits. (B.L.M.)

**190** STUDIES ON THE PENETRATION OF RADIOACTIVE SUBSTANCES FROM FALLOUT INTO GROUNDWATER. Frank, Willy H.; von Hagel, Guenther; Busch, Ermin (Dortmunder Stadtwerke AG, Dortmund, Ger.). Gas-Wasserfach, 105: 254-9(1964). (In German).

Penetration of radioactive fallout into groundwater was studied for several yr by means of catchment basins containing four types of fill, including an alpine soil, soil from the Ruhr Valley, and loess. A 50-cm layer of gravel was used as a base in each basin. Groundwater could be removed from this layer without disturbing the soil overlay. Water was withdrawn only if it amounted to 500 ml or more. Factors studied included the relation between rainfall and groundwater activity, relation between runoff activity and quantity of water that had percolated through the soil, relation of the residual activity of the groundwater to the type of soil profile, study of the depth of penetration of fission products into the soils, and identification of the free and bound activities. The total $\beta$ activity in rain and groundwater decreased slowly after cessation of atmospheric atomic bomb tests. Variations in groundwater activity were less pronounced than in rain. The groundwater from the alpine soil had the greatest activities, and the groundwater from the loess had the least. Activities of the groundwater were diluted by increased rainfall. The soils behaved as high capacity ion exchangers. Much of the activity was due to the K contained in it. Fallout particles did not penetrate farther than the first cm of the soil surface. (BBB)

**191** MEASUREMENT OF THE NATURAL RADIOACTIVITY OF THE AIR (RADON AND THORON) ABOVE THE ATLANTIC OCEAN. Fontan, J.; Blanc, D.; Bouville, A. (Paris Univ., Toulouse). J. Mecan. Phys. Atmos., 5: 107-13(Oct.-Dec. 1963). (In French).

Previous measurements of radioactivity in air over the Atlantic, Pacific, and Indian Oceans are tabulated. New data are also given which are based on measurements made from May 28 to June 28, 1962, on board the meteorological ship France II. Results show that radioactive equilibrium is established over the sea between radon and its descendants, which is seldom obtained over continents at ground level. The thoron concentration is always $\sim 5.5 \times 10^{-15}$ C/l, indicating that the release of thoron from sea water is very low. A study was also made of the variability of radon concentration in the air in terms of the variability of certain meterological parameters. The radon concentration depends on the origin of air masses. Thus, the radon activity is relatively low with west winds and high with east or north winds. Variations in activity may be marked and not always dependent on wind direction changes. Changes in relative humidity, atmospheric pressure, and temperature also seem to influence the radon activity over the Atlantic Ocean. (BBB)

**192** SUMMARY OF FALLOUT MEASUREMENTS IN SWEDEN UP TO SEPT 1964. I. AIR CONCENTRATIONS AND DEPOSITION OF $^{137}$Cs. Lindblom, G. (Foersvarets Forskningsanstalt, Stockholm). 17p. (CONF-747-5). ORAU.

From 4th Symposium on Radioactivity in Scandinavia, Riso, Denmark, Oct. 1964.

Data from measurements of $^{137}$Cs in high-altitude air samples, surface air and precipitation are presented on a monthly basis. Air concentrations and deposition show the well-known and pronounced seasonal variation. The values for 1964 are nearly as high as for 1963 which illustrates the fact that the average retention time of debris in the stratosphere is a function of height of injection. No rapid decrease of average surface concentrations is expected during 1965. (auth)

## Mineralogy

**193** (AEC-tr-6830) GAMMA RADIATION OF URANIUM AND ITS DAUGHTER PRODUCTS IN RADIOACTIVE ORE BODIES. Lyubavin, Yu. P.; Ovchinnikov, A. K. Translated from Vop. Rudn. Geofiz., Min. Geol. i Okhrany Nedr. SSSR, No. 3, 87-94(1961). 11p. Dep. mn. CFSTI $1.00 cy, $0.50 mn. JCL $1.60 fs, $0.80 mf.

The fraction of $UX_1$ and $UX_2$ gamma radiation in the total radiation of the uranium–radium series was determined experimentally to be 3 ± 0.6% for the case of natural deposition of uranium ores. The form of the differential gamma spectrum of uranium and its decay products up to radium in conditions of natural deposition of radioactive ores has also been established. The data indicate that under conditions of natural deposition, with a marked shift of radioactive equilibrium between uranium and radium toward an excess of uranium, there is a practical opportunity for direct determination of the uranium content according to the form of the differential gamma spectra. (P.C.H.)

**194** URANIUM MINERALIZATIONS AND AGE RELATIONSHIPS IN THE PRECAMBRIAN BEDROCK OF CENTRAL AND SOUTHEASTERN SWEDEN. Welin, Eric (Aktiebolaget Atomenergi, Stockholm). Geol. Foren. Stockholm Forhandl., 88: 34-67(1966).

An extensive summary is presented on the genesis of uranium ores in the Precambrian bedrock of Central and southeastern Sweden. The occurrence of uranium in the mineralization described was detected during the uranium boom period 1950–1960. None of these occurrences is of economic value. Several different paragenetic types occur, the most common being the pitchblende-bearing vein fillings and disseminations of uraninite in iron ores of Central Sweden. The well-known Co–Ni–Bi–U paragenesis also occurs, as well as iron deposits possibly representing mechanical accumulations and containing uraninite and monazite supposedly of detrital origin. Alteration of uranium minerals is light although a thin coating of secondary uranium minerals may occasionally be observed. More frequent is the formation of thucholite and radiogalena. To correlate the uranium mineralizations with major Precambrian events, minerals and rocks with stratigraphic key positions were dated by the U/Pb and Rb/Sr whole-rock method. Results of age relation in the Precambrian bedrock of Central and southeastern Sweden are also discussed. (BBB)

**195** DISTRIBUTION OF URANIUM IN ROCKS OF THE UKRAINIAN CRYSTALLINE SHIELD. Gerasimov, Yu. G.; Tuktarova, A. B.; Maidanyuk, V. D. Geofiz. Sb., Akad. Nauk Ukr. SSR, Inst. Geofiz., No. 9, 91-6(1964). (In Russian).

On the basis of the available published data a scheme was created for the distribution of uranium Clark numbers in rocks of the Ukrainian shield. In a few cases, Clark numbers were arbitrarily assigned on the basis of total gamma activity where uranium assays were lacking. The rocks were divided into seven groups according to uranium content in percent: (1) $1 \times 10^{-4}$; (2) 1 to $2 \times 10^{-4}$; (3) 2 to $3 \times 10^{-4}$; (4) 3 to $5 \times 10^{-4}$; (5) 5 to $8 \times 10^{-4}$; (6) 8 to $15 \times 10^{-4}$; and (7) $15 \times 10^{-4}$. The territory of the Ukrainian shield was divided into six regions from the distribution of Clark numbers. Methods based on gamma and beta spectroscopy are recommended in obtaining more uranium assays which are required to substantiate the above conclusions. (TTT)

## Oceanography

*Refer also to abstracts 233 and 256.*

## Seismology

**196** (AD-629431) CUP. Long Range Seismic Measurements [of] VELA UNIFORM. Seismic Data Laboratory Report No. 136. Clark, Don M. (Teledyne, Inc., Alexandria, Va. UED Earth Sciences Div.). Feb. 11, 1966. Contract AF 33(657)-12447. 31p. (VELA-T-2037). CFSTI $3.60 cy, $0.50 mn.

An analysis was made of seismological data from an underground nuclear explosion as a continuing study to

provide information to aid in distinguishing between earthquakes and explosions. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves is included along with other unidentified phases. (auth)

**197** (AD-631285) CAPABILITIES OF THE EXPERIMENTAL LARGE APERTURE SEISMIC ARRAY. Briscoe, H. W.; Capon, J.; Fleck, P. L. Jr.; Green, P. E. Jr.; Greenfield, R. J. (Lincoln Lab., Massachusetts Inst. of Tech., Lexington). Feb. 24, 1966. Contract AF19(628)-5167. 40p. (ESD-TDR-66-47). CFSTI $3.60 cy, $0.50 mn.

An interim appraisal is presented of capabilities of a single Large Aperture Seismic Array (LASA) system to perform the following functions: preprocess arriving seismic signals to increase their detectability, use such preprocessed signals to perform on-line automatic detection and location, process recordings of LASA data off-line, and use the results of the off-line processing for studies of seismic source type. (auth)

**198** (AD-631340) PALANQUIN. Long Range Seismic Measurements. Clark, Don M. (Teledyne Industries, Inc., Alexandria, Va. Earth Science Div.). Apr. 18, 1966. Contract AF33(657)-15919. 29p. (SDL-144). CFSTI $2.00 cy, $0.50 mn.

An analysis of seismological data from an underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions was made. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves is included along with other unidentified phases. (auth)

**199** (AD-632956) BUFF. Long-Range Seismic Measurements [of] VELA UNIFORM. Seismic Data Laboratory Report No. 143. Clark, Don M. (Teledyne Industries, Inc., Alexandria, Va. Earth Sciences Div.). Apr. 5, 1966. Contract AF 33(657)-15919. 43p. (VELA-T-6702). CFSTI $2.00 cy, $0.50 mn.

An analysis was made of seismological data from an underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves is included along with other unidentified phases. (auth)

**200** (AD-632957) RED HOT. Long-Range Seismic Measurements [of] VELA UNIFORM. Seismic Data Laboratory Report No. 145. Clark, Don M. (Teledyne Industries, Inc., Alexandria, Va. Earth Sciences Div.). May 6, 1966. Contract AF 33(657)-15919. 54p. (VELA-T-6702). CFSTI $3.00 cy, $0.50 mn.

An analysis was made of seismological data from an underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves is included along with other unidentified phases. (auth)

**201** (AWRE-O-43/66) ABSORPTION OF ELASTIC WAVES: AN OPERATOR FOR A CONSTANT Q MECHANISM. Carpenter, E. W. (Atomic Weapons Research Establishment, Aldermaston (England)). Oct. 1966. 16p. Dep. mn. BIS $0.50, HMSO 2s. 6d.

A theoretical analysis is given of the absorption of elastic waves in the frequency range of seismological interest. The impulse response of a system satisfying the constant Q hypothesis is calculated and the results discussed. (auth)

# ENGINEERING

## Nuclear Explosions

*Refer also to abstracts 198, 252, 338, and 339.*

**202** (AD–635477) NUCLEAR WEAPONS EFFECTS: COMPILATION OF ABSTRACTS. Report No. 3. Ksander, Yuri (Library of Congress, Washington, D. C. Aerospace Technology Div.). Apr. 19, 1966. 35p. (ATD–66-45; TT–66-61761). CFSTI $2.00 cy, $0.50 mn.

A compilation of abstracts on the effects of nuclear weapons is presented. The abstracts are arranged in three sections. Section I contains abstracts on the structure and parameters of shock waves in gases, Section II the propagation of strong shock waves and their interaction with materials, and Section III shock waves in the stars and interstellar space. (auth)

**203** (RM–5073-TAB) THE SIMULTANEOUS FLAMMABILITY OF WILDLAND FUELS IN THE UNITED STATES. Huschke, R. E. (RAND Corp., Santa Monica, Calif.). Sept. 1966. Contract AT(04-3)-414. 158p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

Probabilistic estimates are calculated for the quantities of U. S. wildland fuels that would be simultaneously flammable at a given time of year. "Flammability" is quantitatively represented by "burning indices," which differ for different fuel types; the degree of flammability is determined by arbitrary selection of "critical" levels on the burning-index scales. The burning indices are derived from a ten-year set of daily weather observations at 89 locations in the United States. It was necessary to contrive, especially for this study, (a) a national wildland-fuel distribution, (b) a phenological basis for calculating growth-stage-dependent burning indices, and (c) a method for simulating the fire-depressing effect of snow cover. All of these devices are described in detail. The principal results graphically depict the annual cycles of simultaneously flammable area for eight different fuel type combinations at several frequency levels. Additional graphs enable quantitative estimates to be made of the way the principal results can be varied by selection of different "critical" levels of the burning indices. (auth)

**204** (SC-RR–65-657) THREE POSSIBLE ENGINEERING APPLICATIONS OF NUCLEAR EXPLOSIVES IN THE SHALE OIL INDUSTRY. Smith, R. E. (Sandia Corp., Albuquerque, N. Mex.). Oct. 1966. Contract AT(29-1)-789. 25p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Three methods are described by which nuclear explosives might be used to enhance the obtaining of petroleum products from shale oil deposits. The three methods are construction of an underground retort by nuclear explosives, limited use of the nuclear block cave mining methods to enhance an in situ combustion recovery operation, and limited use of the nuclear block cave mining method to make an open pit mining method feasible. (auth)

**205** (UCID–15008) FREE-FIELD PEAK PARTICLE MOTIONS FROM UNDERGROUND NUCLEAR EXPLOSIONS IN ALLUVIUM. Preston, R. G. (Lawrence Radiation Lab., Univ. of California, Livermore). July 27, 1966. Contract W-7405-eng-48. 6p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Scaled free-field radial peak particle accelerations, velocities and displacements associated with subsurface motions from underground nuclear explosions in unsaturated alluvium are given. Curves were plotted from data derived from Fisher, Ringtail, Hognose, and Haymaker shots. These curves are not valid for shots in alluvium in west Yucca Fault where the alluvium is characterized by higher densities and compressional velocities. (F.S.)

**206** PLOWSHARE IN UNIVERSITY PROGRAMS. Talley, Wilson K. 5p. (CONF-660606–48). ORAU. Gmelin, AED-CONF-66-203-96.

From American Nuclear Society Meeting, Denver.

University courses and research in the constructive uses of nuclear explosions are summarized. Prospects for more courses involving more disciplines, such as physics, chemistry, geology, mathematics, meteorology and engineering are evaluated. (F.S.)

**207** COMMERCIAL APPLICATIONS OF NUCLEAR EXPLOSIVES. Coffer, H. F.; Aronson, H. H. (CER Geonuclear Corp., Las Vegas, Nev.). 18p. (CONF-660606–49). ORAU. Gmelin, AED-CONF-66-203-100.

From American Nuclear Society Meeting, Denver.

Potential uses of nuclear explosives with emphasis on gas well stimulation are discussed. The uses of nuclear explosives to recover oil from oil shale, create underground storage capacity for gas and waste disposal, break up large ore bodies for underground leaching, and for evacuation of canals and harbors are summarized. Problems which must be met before nuclear explosions become common in commercial applications are discussed. Such problems consist of determining the potential damage from shock waves and the type of radiation problem, if any, which must be overcome. In addition, the most economical methods of fielding and firing the devices must be worked out to maximize the profit potential from the use of this tremendous power source. (F.S.)

## Facilities and Equipment

*Refer also to abstract 462.*

**208** (BNL–10652) THE PRODUCTION TEST IRRADIATION OF 30,000 POUNDS OF BACON. Manowitz, B.; Galanter, L.; Loeb, W.; Milau, J.; Rizzo, F. (Brookhaven National Lab., Upton, N. Y.). July 1966. Contract AT(30-2)-Gen-16. 53p. (CONF-660903–2). Dep. mn. CFSTI $3.00 cy, $0.50 mn.

From American Inst. of Chemical Engineers Meeting, Atlantic City.

The use of the High Intensity Radiation Development Laboratory (HIRDL) at BNL for processing shelf stable, γ irradiated, sliced, canned bacon is described. The source is composed of four holders containing 39 cobalt-60 sources mounted upright on the source elevator. An absorber constructed of Al and stainless steel is used. The γ dose did not exceed 5.6 megarads and was not less than 4.5 megarads. Average retention time was 2 hrs. Temperature during irradiation did not exceed 80°F. The HIRDL was not designed for food sterilization, however, its performance was satisfactory. The conveyor was the main source of trouble. (F.S.)

**209** (GEAP–5122) HIGH-TEMPERATURE WATER SOLIDS CONCENTRATOR. Fitzsimmons, M. D. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). Feb. 1966. Contract AT(04-3)-189. 16p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A description is given of the physical arrangement and operation of a device which extracts nonvolatile substances from a water sample by evaporation. The process is unique in that the evaporation is performed at system pressure and the corresponding saturation temperature without cooling of the sample between the source and the sample processing device. (auth)

**210** (NAA-SR-Memo-11961) ANALYSIS OF SAFETY AND RELIEF VALVE INSTALLATIONS IN THE SCTI MAIN STEAM LINES. Bonyhady, K. A. (Atomics International, Canoga Park, Calif.). May 10, 1966. Contract AT-11-1-GEN-8. 49p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

A vibration analysis was made of the safety and relief valve installations in the 4-in. main steam pipeline of the Sodium Components Test Installation (SCTI). During startup of the SCTI steam section, some safety valves showed undesirable vibrational behavior. This analysis was made to determine improvements which will correct the dynamic load problems encountered. The modifications recommended will permit keeping the plant down time to a minimum and will involve minimum labor and material costs. They will assure proper operation of the main steam line at the rated plant conditions. The following improvements are recommended: (1) move the two high-pressure steam safety valves next to the steam generator steam outlet nozzles, (2) anchor two points of the main steam lines at the intermediate and at the low pressure section safety valves, (3) adjust hanger loads (affected by the above modifications) to agree with the detailed piping hangerload and thermal stress computations, and (4) add vibration dampeners (snubbers) to reduce the expected vibrations and resist the additional piping loads from the electromatic safety valve. (auth)

**211** (TID–4100(Suppl.35)) SUPPLEMENTAL INSERT SHEETS FOR ENGINEERING MATERIALS LIST. Sachs, Francis L. (ed.) (Division of Technical Information Extension (AEC), Oak Ridge, Tenn.). Oct. 1966. 70p. Dep. DTI Extension Free.

Forty-one packages of engineering materials on hot laboratory equipment, instruments, metallurgical equipment, radiation detectors, reactors, accelerators, biological equipment, shielded containers, and space equipment are announced in this supplement for inclusion in TID-4100. (F.S.)

**212** (ORNL-tr–1351) KA INTERSPAN CABLE SYSTEM OF 44-60 WIRES. Matthey de l'Etang, [William]. Translated for Oak Ridge National Lab., Tenn., from Ann. Inst. Tech. Batiment Trav. Publics, 18: 1344-8(Oct. 1965). 10p. Dep. mn. JCL $1.10 fs, $0.80 mf.

The fabrication of high-strength cables for use in prestressed concrete is discussed. Such cables permit a reduction in the cable size to the minimum permitted by building codes, with a corresponding reduction in space requirements. An anchoring system is described in which oval ribbed wires are arranged in layers of four between steel plates. Anchoring of the wires is done by transverse locking of high-strength bolts 24 mm dia passing through the plates. (R.C.K.)

**213** (ORNL-tr–1352) HIGH-STRENGTH CABLES OF THE INCERC TYPE. Gaina, N.; Tannenbaum, M. Translated for Oak Ridge National Lab., Tenn., from Ann. Inst. Tech. Batiment Trav. Publics, 18: 1349-51(Oct. 1965). 8p. Dep. mn. JCL $1.10 fs, $0.80 mf.

Methods of increasing the strength of cables used in prestressed concrete are discussed. These methods include the retention of the number of component parts of the cable, but increasing their cross section, and the assembly of a larger number of components of reduced cross section in the same cable. The studies resulted in the Incerc Prestressing Process which assures the concomitant stressing of ace wires in a cable and the anchoring of all cable wires in the same immobile metal anchoring device. (R.C.K.)

**214** (ORNL-tr–1353) HIGH-STRENGTH FREYSSINET CABLES. Guyon, Y. Translated for Oak Ridge National Lab., Tenn., from Ann. Inst. Tech. Batiment Trav. Publics, 18: 1352(Oct. 1965). 5p. Dep. mn. JCL $1.10 fs, $0.80 mf.

The development of high-strength cables for the construction of bridges and nuclear reactors is discussed. An important consideration in the development of high-strength cables is the development of a practical and rapidly operating anchor. A major parameter to be considered is not the anchored stress before rupture, but the elongation of the cable at rupture. (R.C.K.)

**215** GAMMA RADIATION FACILITY OF STATIONARY TYPE. Ney, Wlodzimierz (Inst. of Nuclear Research, Warsaw). Nukleonika, 11: 415-20(1966). (In Polish).

A stationary γ facility of 1000-C $^{60}$Co for physico-chemical investigations is described. The facility utilizes new construction ideas such as nonelastic source pipes, the construction of which gives the possibility of changing the shape and size of the source, mechanical changing of the radioactive units, and movable biological shields enabling repairing and dismounting of the facility. (auth)

**216** AUTOMATIC SAMPLER FOR URANIUM MATERIALS (Engineering Materials). (Goodyear Atomic Corp., Portsmouth, Ohio). (CAPE–1487).

22 drawings.

The sampler is used for uranium oxide or uranium nitrate powders and fits easily into a standard laboratory-type fume hood to minimize health hazards. The dimensions of the sampler are ~21½ × 22 × 47⅝ in. A control circuit permits either automatic or manual operation of the unit which consists of a power-driven enclosed auger that extracts 50–75 gram core samples from the material container. The container used is 6½ in. high and 5 in. OD. Larger containers may be used. (For details see TID-4100 Suppl. 37) (F.S.)

**217** AIR BEARING SPINDLE FOR NUMERICALLY CONTROLLED TURNING MACHINE (Engineering Drawings). (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). (CAPE–1488).

16 drawings.

The spindle is used to minimize spindle growth as well as achieve low operating temperatures, good reliability, stiffness, and rotational accuracy. The spindle is comprised of a 7-in. dia journal bearing, 12-in. dia thrust bearing and a 32-in. shaft. Porous graphite is used for bearing caps to distribute air flow. The spindle has greatly improved the machine precision. (For details see TID-4100 Suppl. 37) (F.S.)

**218** QUADRUPOLE MAGNET WITH REDUCED LATERAL DIMENSION. Jackson, J. W. (to U. S. Atomic Energy Commission). U. S. Patent 3,284,744. Nov. 8, 1966.

A quadrupole magnet is described in which the lateral dimension is reduced by eliminating yokes along the lateral width and compensating elsewhere for this reduction of yoke material. Four-fold symmetry of the magnet is retained by adding yoke material along the dimension at right angles to the width. (AEC)

**219** DEVICE FOR OSCILLATION AND ROTATION OF NONCIRCULAR BODIES. Curnow, Erik K.; Gunter, Alfred W. (to Atomic Energy of Canada Ltd.). Canadian Patent 739,184. July 26, 1966.

An apparatus was designed to rotate and/or oscillate a cluster of units during irradiation of products having polygonal prismatic configurations. The components required are, a support, a guide which restrains movement in certain directions, a means for imparting intermittent oscillation and other mechanical means for controlling movement so that radiation is received equally by all units. This is accomplished by keeping the products under irradiation at approximately equal distances from the source during the movement cycle. (F.S.A.)

## Heat Transfer and Fluid Flow

**220** (AE–239) VOID MEASUREMENTS IN THE REGIONS OF SUB-COOLED AND LOW-QUALITY BOILING. PART 2. HIGHER MASS VELOCITIES. Rouhani, S. Z. (Aktiebolaget Atomenergi, Stockholm (Sweden)). July 1966. 62p. Dep. mn.

Tables of experimental data obtained in void measurements are presented. The data are from measurements in a vertical annular channel with 25 mm OD and 12 mm ID at a heated length of 1090 mm. The experiments covered pressures from 10 to 50 bars, mass velocities from 650 to 1450 kg/m²/sec, heat fluxes from 60 to 120 w/cm², sub-

coolings from 30 to 0°C, and steam qualities from 0 to 12%. Tabular data are included on the inlet temperatures and measured wall superheat. (auth)

**221** (AE–243) ON SHEAR STRESS DISTRIBUTIONS FOR FLOW IN SMOOTH OR PARTIALLY ROUGH ANNULI. Kjellstroem, B.; Hedberg, S. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Aug. 1966. 70p. Dep. mn.

It is commonly assumed that for turbulent flow in annuli the radii of zero shear and maximum velocity are coincident. By inspection of the differential equations for such flow and by an integral analysis it is shown that this is not necessarily true. To check whether important differences could occur, experiments were made in which velocity and shear stress distributions were measured in one smooth and two partially rough annuli. The results show no difference in the radii for the smooth annulus, but for the partially rough annuli there was a small but significant difference. This difference explains the breakdown of Hall's transformation theory reported by other investigators. The error introduced by use of Hall's theory, however, is small, of the order of 10% or less. (auth)

**222** (EUR–2963,e) FORCED CONVECTION BURNOUT AND HYDRODYNAMIC INSTABILITY EXPERIMENTS FOR WATER AT HIGH PRESSURE. PART II. PRESENTATION OF DATA FOR WATER FLOWING UPWARD ALONG A UNIFORMLY HEATED ROD IN A SQUARE UNHEATED DUCT. Campanile, A.; Galimi, G.; Goffi, M. (Societe Ricerche Impianti Nucleari, Saluggia (Italy). Centro Ricerche Nucleari). May 25, 1966. 28p. Dep. mn.

N. 110 burnout data for water flowing upward, in conditions of forced convection at high pressure, in a vertical square annular channel were taken over a wide range of mass flow rates, inlet subcooling, and pressure. The data refer to a configuration of the cross section geometry in which a heater rod is centered in a square unheated channel. Only two data could be taken with eccentric transverse position of the rod in the flow channel before physical destruction of the heater. (auth)

**223** (EUR–3114.e) INVESTIGATION ON SOME PARAMETERS INFLUENCING NON-UNIFORM HEAT FLUX DNB PREDICTION. Previti, G.; De Bernardi, M. (FIAT, Turin (Italy). Sezione Energia Nucleare. ANSALDO S.p.A., Genoa (Italy)). Aug. 1966. 52p. Dep. mn.

Recent tests conducted by various laboratories have shown a marked influence of the heat flux distribution both on departure from nuclear boiling (DNB) power and location point, and a theoretical correction factor has been proposed in order to predict nonuniform heat flux DNB conditions from corresponding uniform flux data. Work was conducted to define the field of applicability of the theoretical approach, and to point out the role of some important parameters such as DNB length and pressure and to modify the theoretical analysis for the high quality region. An analytical expression for factor $C = (h/\rho V \text{ s } Cp)$ in bubbly flow region has been derived. (D.L.C.)

**224** (IN–1027) STEADY STATE HEAT CONDUCTION WITH IRREGULAR SHAPED BOUNDARIES. Scheffler, W. A. (Idaho Nuclear Corp., Idaho Falls). Sept. 1966. Contract AT(10-1)-1230. 10p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The effect of irregular shaped boundaries on the temperature distribution in a solid is calculated. The method used to calculate the effect of the boundary perturbation is straightforward and of a general nature. The application of such a method to problems in heat conduction will provide temperature corrections to thermocouples due to solid boundary irregularities. (auth)

**225** (KAPL-M–6532) LION: TEMPERATURE DISTRIBUTIONS FOR ARBITRARY SHAPES AND COMPLICATED BOUNDARY CONDITIONS. Schmid, J. R.; Lechliter, G. L.; Fischer, W. W. (Knolls Atomic Power Lab., Schenectady, N. Y.). July 27, 1966. Contract W-31-109-eng-52. 78p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

LION is a digital computer program which will solve three-dimensional transient and steady-state temperature distribution problems. The input consists of geometry, physical properties, boundary conditions, internal heat generation rates, and coolant flow rates as a function of time. In addition to solving problems of heat conduction in a structure, LION can handle forced convection, free convection, and radiation or a combination of these at the surface of the structure. The output consists of complete nodal temperature distributions along with surface fluxes and surface heat transfer coefficients. An option is included in the program for determining the mean temperature in any specified section of the structure. The first forward difference method is used in obtaining the solution. The approximate running time on the CDC 6600 is steady-state—1 min/10 nodes, and transient—1.5 min/10 nodes. (auth)

**226** (NAA-SR-Memo–11941) SECONDARY SODIUM PIPING DESIGN WITHOUT BELLOWS. Sodium Component Test Facility Feasibility Study Report. Landler, G. (Atomics International, Canoga Park, Calif.). May 2, 1966. Contract AT(11-1)-Gen-8. 88p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Includes Appendices A thru F.

Bellows-free design of the secondary sodium system in the SCTI is feasible. The result of the study is an isometric layout of the sodium inlet and outlet lines of the B & W steam generator, without bellows type expansion joints. The feasibility studies performed on these piping configurations demonstrated compliance with the requirements of the American Standard Code for Pressure Piping ASA B31.1 and with the manufacturers' requirements assuring structural integrity of the process equipment. A review by the C.F. Braun and Company has found the piping configurations reasonable and sound. Supporting studies related to the adequacy of the equipment arrangement and to compliance with process requirements are included. (auth)

**227** PROPAGATION AND THE WAVE FORM OF THE VAPOR VOLUMETRIC CONCENTRATION IN BOILING, FORCED CONVECTION SYSTEM UNDER OSCILLATORY CONDITIONS. Zuber, Novak; Staub, F. W. (General Electric Co., Schenectady, N. Y.). Contract AT(04-3)-189. Int. J. Heat Mass Transfer, 9: 871-95(Sept. 1966).

Various aspects and characteristics of the void propagation equation are discussed. This equation predicts the transient response of the volumetric concentration to perturbations of power input, inlet flow, system pressure, thermodynamic nonequilibrium, compressibilities of the vapor and of the liquid, and body forces acting on the two-phase mixture. This transient response is predicted as functions of space and time. Solutions of the void propagation equation are derived for the following operating conditions: constant power and inlet flow, oscillatory power input, oscillatory inlet flow, and oscillatory power and oscillatory flow. It is shown that perturbations of the mixture density are propagated through the two-phase mixture by the velocity of kinematic waves. Expressions which predict the rate of propagation of these waves and which are appropriate to the operating conditions listed above are presented. The finite rate of propagation of kinematic waves introduces a delay time which characterizes the response of the volumetric concentration to various perturbations. The delay times, appropriate to the operating conditions enumerated above, are also presented. The predicted results are compared to available experimental data; satisfactory agreement is shown. (auth)

**228** STABILITY OF DRY PATCHES FORMING IN LIQUID FILMS FLOWING OVER HEATED SURFACES. Zuber, Novak; Staub, Fred W. (General Electric Co., Schenectady, N. Y.). Contract AT(04-3)-189. Int. J. Heat Mass Transfer, 9: 897-905(Sept. 1966).

Criteria are derived which predict the stability of dry patches forming in thin liquid films flowing over a heated surface. The analysis of Hartley and Murgatroyd applicable to isothermal films is extended to include the effects of vapor thrust and of thermocapillarity. Numerical eval-

uations are carried out that indicate the relative importance of the various effects in conjunction with typical heated water and liquid metal films. The results show that for liquids of high wettability (for example liquid metals) the thermal effects become dominant in determining the stability of dry patches. (auth)

**229** LONGITUDINAL LAMINAR FLOW IN AN ARRAY OF CIRCULAR CYLINDERS. Schmid, J. (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez). Int. J. Heat Mass Transfer, 9: 925-37(Sept. 1966).

A theoretical investigation of longitudinal developed laminar flow in an infinite square array of circular cylinders, the array being bounded on one side by a wall, parallel to the cylinder axes, is described. The influence of the array pitch (2b) and the distance of the wall from the first row of cylinders ($b_1$) on the flow rate of the medium through the individual cells of the array is studied and the mutual influence of the flow rate in individual cells one upon the others is investigated. The quantity b has been varied in the range from 1.5 R to 2.5 R (R being the cylinder radius) and the distance from the wall has been varied from $b_1 = b$ (the first cell being square) to such values of $b_1$, where the ratio of hydraulic diameters of the first cell and a cell within the lattice ($\xi = d_1/d_i$) reaches a value of 1.3. From the calculation it follows that the mutual influence of the individual cells is relatively small. Variations of the flow rate in the first two rows of cells reach a value of 1 per cent only for relatively large pitches ($b > 2.5$ R) and for cases, where the first cell differs greatly in the hydraulic diameter from the cells inside the array ($\xi > 1.3$ and $\xi < 0.6$). The influence of the third row of cells is negligible in the range of parameters considered. (auth)

**230** AN EXPERIMENT STUDY OF LIQUID FILM COOLING ACCOMPLISHED BY DUAL SLOT INJECTION. Warner, C. F. (Purdue Univ., Lafayette, Ind.); Guinn, G. R. Contract Nonr 1100 (21). J. Spacecraft Rockets, 3: 1547-9(Oct. 1966).

Liquid film cooling as a means of protecting the internal surfaces of chemical and nuclear rocket motors is discussed. Protection is achieved by interposing a thin continuous liquid film between the surface and the hot gaseous stream. The coolant is injected through slots or holes onto the surface to be cooled and is swept downstream by the action of the main gas stream until it is consumed by evaporation. It was found that dual slot injection effectively reduces the quantity of coolant required to film-cool a given length of surface compared to that required when a single slot is used. Reductions of 10 to 20% in coolant injection rate can be realized for either water or alcohol coolant. (R.C.K.)

**231** LIMITATIONS ON GASEOUS NUCLEAR ROCKET $I_{sp}$ DUE TO NOZZLE COOLANT REQUIREMENTS. McLafferty, George H. (United Aircraft Research Labs., East Hartford, Conn.). J. Spacecraft Rockets, 3: 1515-22(Oct. 1966).

An analysis was conducted to determine approximate limitations on the specific impulse ($I_{sp}$) of advanced nuclear rocket engines due to hydrogen transpiration coolant flows in the exhaust nozzle. Included in the investigation were analyses to determine the effects of changes in the following: nozzle stagnation pressure, the enthalpy rise of the transpiration coolant fluid, the Stanton number reduction due to transpiration cooling, the technique employed for calculating radiant heat transfer, and the amount of mixing between the transpiration coolant flow and the primary flow. The results indicate that coolant flow requirements will be governed primarily by convective heat transfer at low values of $I_{sp}$ and by radiant heat transfer at high values of $I_{sp}$. The latter appears to limit the maximum $I_{sp}$ of a hydrogen-propellant nuclear rocket engine to values between approximately 2500 and 5000 sec.

**232** ACCELERATION OF THE CONVERGENCE OF SUCCESSIVE OVER-RELAXATION BY ORDER OF MESH POINT SCANNING IN THE SOLUTION OF THE DIFFUSION EQUATION FOR TRANSIENT HEAT TRANSFER. Cudahy, G. F. (Holloman AFB, N. Mex.); Kaplan, B. 26p. (CONF-660606-50). ORAU. Gmelin, AED-CONF-66-203-90.

From American Nuclear Society Meeting, Denver.

A method is presented for improving the rate of convergence of the iterative solution of the 2 dimensional five point implicit finite difference representation of the diffusion equation of transient heat transfer through the use of various scanning techniques. With boundary and initial conditions specified, the equation forms a set of N simultaneous equations with N unknowns. Each unknown is the temperature of an interior node. Solutions are stable for all time increments and at any time step $\Delta t$ may be picked for the solution of the finite difference equation and any errors will be bounded. (F.S.)

## Isotope Technology

*Refer also to abstract 354.*

**233** (AGN-8163(Vol.2)) RADIOISOTOPE APPLICATIONS IN HYDROSPACE. VOLUME II. PROGRAM PLAN. Final Report. (Aerojet-General Nucleonics, San Ramon, Calif.). Nov. 1965. Contract AT(04-3)-368. 43p. Dep. mn, CFSTI $2.00 cy, $0.50 mn.

A program plan for the development and testing of a demonstration Radioisotope Submersible Engine (RISE) is presented. The program is directed towards the investigation of a radioisotope dynamic conversion power plant in the range of 2 to 20 kw(e). General criteria have been established for a self-contained power supply capable of operating for an extended time for missions connected with the exploration and utilization of the ocean. (R.C.K.)

**234** (MND-3283-3) RFD-2 FLIGHT TEST PROGRAM. Supplementary Analysis Report. Culotta, A. J.; Fernandez, I.; Anderson, D. C. (Martin Co., Baltimore, Md.). Jan. 1966. Contract AT(30-1)-3283. 77p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The results of a study whose objective was to calculate the reentry behavior of simulated radioisotopic fuel elements released during Reentry Flight Demonstration Number Two, conducted in the fall of 1964, to compare calculated burnup times and altitudes with those observed in the reentry experiment is presented. Estimates of trajectory and burnup for the four external capsules were obtained assuming in each case end-over-end tumbling and stable, side-on motion for the reentry bodies. These results included the observed burnup conditions; however, in those cases for which burnup was predicted the variation in burnup altitude between the extremes of assumed rotational motion was in the neighborhood of 40,000 feet. Uncertainties in prediction techniques as gross as this are not permissible, in general, for nuclear safety applications. Calculations have employed semi-empirical techniques to infer the detailed rotational motion of the reentry bodies. Wind tunnel data yielding inviscid pressure distributions as a function of capsule attitude were supplemented and extended by the Newtonian theory. Viscous corrections to pressure distributions were obtained by an approximate, theoretical technique. These pressure distributions were integrated to obtain appropriate forces and pitching moments for the reentering capsules, permitting parametric evaluation of rotational motion as a function of initial pitch, yaw, and pitch and yaw rate conditions. For the subset of initial conditions yielding trajectories consistent with the observed trajectories, aerothermodynamic calculations were performed to determine burnup times and altitudes to compare with observed data. The results show that those motions yielding trajectories consistent with observed trajectories were limited to side-on reentry with small oscillations in pitch, and that this type of motion was predictable for a physically reasonable class of initial conditions. For this type of rotational motion comparison of calculated and observed burnup times showed that theoretical uncertainties (owing primarily to thermal averaging techniques) were nearly equivalent to observational uncertainties and were on the order of 3 seconds (approximately 9000 feet in altitude) in magnitude. Calculations

agreed with experiment within this error range. Calculated viscous corrections were important in deriving the rotational motion of the present cylindrical capsule configuration and may be even more significant for other configurations. These corrections could only be approximated in the present work and no conclusion as to the validity of these corrections could be drawn by comparison with RFD-2 observations. Experimental data are required to minimize uncertainty in determining viscous perturbations on pressure distributions. (auth)

**235** (PAEC/CHEM–101) GRAFT COPOLYMERISATION ON WOOD PINUS LONGIFOLIAS USING $^{60}Co$ GAMMA RAYS. Awan, M. H.; Husain, Ather (Atomic Energy Centre, Lahore (Pakistan). Chemistry Div.). Oct. 16, 1965. 56p.

Wood pieces from Pinus Roxburghii (Pinus Longifolias) were subjected to graft copolymerization with styrene, methylmethacrylate and acrylonitrile. The grafted samples were found to be more resistant to the attack of Aspergillus niger. Placed in moist soil in the open for about eight months, these pieces showed no growth of fungi. Water repellant properties were increased during grafting. The effect of irradiation on the dimensional stability and wood working quality of the wood samples is discussed. Various methods of graft copolymerization, as well as the tests carried out on the grafted samples, are described. (auth)

**236** (STL–517-0038) RADIOISOTOPE PROPULSION TECHNOLOGY PROGRAM: POODLE. Quarterly Progress Report, October 1–December 31, 1965. (TRW Systems, Redondo Beach, Calif.). Jan. 1966. Contract AT(04-3)-517. 53p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

Progress on the Radioisotope Propulsion Technology Program (Poodle) is reported. Work during the reporting period included capsule creep studies, research on noble metal capsule claddings, analyses of nozzle performance, and heat source simulation studies. (R.C.K.)

**237** USE OF AMPOULE WITH HYDRAULIC BLOCK IN LARGE GAMMA-RADIATION INSTALLATIONS FOR CHEMICAL PURPOSES. Bykhovskii, A. V.; Drozdov, V. E.; Lisov, G. N. At. Energ. (USSR), 21: 63-4(July 1966). (In Russian).

Ampoules developed for gamma sources stored under water in irradiation facilities are described. Two types of ampoules have been developed for use in installations with and without manipulators. If the source is always under water, a system of two cylindrical containers is used; if the source is removed from the water during irradiation experiments, a third container is provided to maintain the integrity of the hydraulic lock. With manipulators, all charging operations may be carried out under the protective water layer. Removal of heat is provided. (TTT)

**238** MODIFIED METHOD FOR THE DETERMINATION OF AQUIFER PARAMETERS USING RADIOACTIVE ISOTOPES. Hazzaa, I. B. (Middle Eastern Regional Radioisotope Centre for the Arab Countries, Cairo). Int. J. Appl. Radiat. Isotop., 17: 583-5(Oct. 1966).

The method for measuring the lowering of water levels in wells during pumping was modified to overcome the difficulties that appeared during several field experiments. A $\gamma$ source placed outside the well is connected through a set of pulleys to a float on the water surface in the piezometer well; and variation of the counting rate caused by elevating the source due to the lowering of the float when pumping from a nearby well is registered using a scintillation detector. The method was applied on deep wells and lengthy draw-downs giving prompt and sensitive register. (auth)

**239** IRRADIATED WOOD-PLASTIC PARTS ARE TOUGH AND DIMENSIONALLY STABLE. Mater. Design Eng., 64: No. 4, 68-9(Oct. 1966).

The production of composites by the impregnation of wood with a liquid plastic and then irradiating the material with $\gamma$ rays from a $^{60}Co$ source is described. Irradiation of composite materials raises resistance to swelling and warping by water, and provides mechanical properties 2 to 3 times higher than unmodified wood. (R.C.K.)

**240** BETA RAY LIGHT SOURCE STRUCTURE. Feuer, Irving (to Canrad Precision Industries, Inc.). U. S. Patent 3,260,846. July 12, 1966. Filed Apr. 9, 1963.

A light source is described which utilizes one or more regions of phosphors in combination with a heavy metal reflecting region providing an efficient means for converting radioactive energy into light. A light source utilizing a weak beta source has a front phosphor region of sufficient depth to absorb the beta particles, but not the light generated by the phosphors. A heavy metal reflecting region serves to backscatter the beta particles and reflects the light. The beta particles then further excite the forward phosphor and the energy is discharged as light. (F.S.)

## Materials Testing

*Refer also to abstracts 170, 337, and 1228.*

**241** (EURAEC–1695) ULTRASONIC EXAMINATION OF WELDED JOINTS IN STEEL PLATE OF THICKNESSES UP TO 300 mm. Quarterly Progress Report No. 18. de Sterke, A. (Roentgen Technische Dienst N. V., Rotterdam (Netherlands)). Aug. 9, 1966. 31p. (EUR–2883; CONF-660718–1). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

From International Inst. of Welding, 19th Annual Assembly, Delft, Netherlands.

Experiments were made on welds in steel having thicknesses of 100, 200, and 300 mm, using an ultrasonic pulse-echo system. The various factors which influence the flaw detectability were investigated, including surface condition, the condition of the parent metal, the position and orientation of defects and their size. It is shown that surface roughness not only affects acoustic coupling but also causes beam distortion. Laminar flaws, which are more readily found in thick plates, obscure the image of the internal weld condition when they occur in the vicinity of the weld. The position, orientation, and size and width of defects have a combined effect on detectability. Although in one case very small defects can be found in welds even up to 300 mm thick, in other cases the detection of gross defects in thinner sections may call for special techniques. The problem of the sensitivity setting is discussed against the background of the above parameters. For adequate correlation of data found during scanning, the information recording should be coupled to mechanized scanning systems. The evaluation of the ultrasonic results points to the need for special recording systems, able to plot indications of defects in terms of position and length, as well as their location in cross sectional view. Several approaches to this problem are indicated, such as pen-records, dynamic screen images, B-scope presentation, and the use of a facsimile recorder. (auth)

**242** (WERL–0029-3) ANALYTIC DETERMINATION OF STRESS INTENSITY FACTORS FOR THE MANJOINE BRITTLE FRACTURE TEST SPECIMEN. Wilson, W. K. (Westinghouse Research Labs., Pittsburgh, Pa.). Aug. 26, 1965. Contract AT(11-1)-Gen-14. 45p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The stress intensity factor for the standard Manjoine brittle fracture test specimen is determined by the collocation method and the Muskhelishvilli complex variable method. These methods are also applied to specimens having different geometric proportions than the standard Manjoine specimen. Some of the results of this analytic investigation are compared with those obtained from an experimental compliance method. Also, some simplified analytic models are presented which may be used to approximate the stress intensity factors for geometries of

Manjoine specimens not specifically covered in this study. (auth)

**243** PRINCIPLES AND APPLICATIONS OF THE γ-RADIOGRAPHY APPARATUS (TYPE GAMMAMAT) FOR MATERIAL TESTING. Sauerwein, K. (Institut fuer Gesteinshuettenkunde der RWTH, Aachen. Forschungsinstituts der Feuerfest-Industrie Bonn, Aachen). Deut. Keram. Ges., 43: 457-62(June 1966). (In German).

Gamma radiography is described and contrasted with x-ray and ultrasonic testing. The most common γ ray emitters are reviewed. Three principal types of radiographic equipment are described. Applications of radiographic techniques include investigation of the texture of structural units, concrete making, welding, determination of density, porosity, moisture content of structural materials, and testing materials for cavities and foreign inclusions. (R.C.K.)

**244** SCINTILLATION METHOD OF FLAW INDICATION IN THE BETATRON DEFECTOSCOPY OF THICK-WALLED WELD JOINTS. Vorobev, V. A.; Gorbunov, V. I.; Pokrovskii, A. V. (Tomsk Polytechnic Inst., USSR). Svarochn. Proizv., No. 7, 14-15(1965). (In Russian).

A flaw detector with scintillation counters for the high-speed scanning of weld joints up to 400 mm thick, using a betatron as the radiation source, is described. The flux of bremstrahlung from a betatron passes through the scanned object and through the collimator of the radiation detector striking a NaI(Tl) scintillation counter and a photomultiplier. The unit also contains a circuit for recording and processing data. The detectability of weld joint flaws is a function of the attenuation factor of radiation at the site of the flaw. With this method, it is possible to reliably detect weld joint flaws beginning with a volume of 60–80 $mm^3$. The type and shape of the flaw are recorded on x-ray film. (ATD)

**245** DEVELOPMENT OF ULTRASONIC INSPECTION TECHNIQUES FOR TAPERED TUBING. McClung, R. W.; Cook, K. V. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. Mater. Eval., 24: 573-6 (Oct. 1966). (ORNL-P-1534).

Improved performance from heat exchangers may be obtained with the use of tubing that has a constantly varying diameter along its length. Some of the tubing used exhibits a reverse taper; its diameter varies from large at one end to small near the center and back again to large on the other end. Until recently, the available inspection systems were inadequate for the detection of discontinuities in the tapered tubing. However, development of new ultrasonic techniques and equipment at the Oak Ridge National Laboratory has provided a useful solution for this inspection problem. A mechanical scanning system that maintained proper ultrasonic beam orientation even though the diameter varied during the scan was developed. Associated circuitry provided an audible alarm and a "B" scan presentation to indicate discontinuities. This system has been successfully applied to the inspection of both 0.009-in.- and 0.050-in.-wall tapered tubing. Reproducible sensitivity to discontinuities 0.0005 in. in depth was demonstrated for the thin-wall tubing. (auth)

**246** RADIOGRAPHIC INSPECTION OF SEMICONDUCTORS AND COMPONENTS. Clark, L. D.; McCullough, R. E. (Texas Instruments, Inc., Dallas). Mater. Eval., 24: 577-82(Oct. 1966).

Radiographic techniques used to detect small particles, extraneous leads, and minor construction defects in transistors and diodes are discussed. A laboratory, established to nondestructively test airborn electronic equipment, was described. A penetrameter is described which incorporates a three-dimensional effect for distortion measurements and uses gold wires to simulate internal leads of semiconductor devices, and particles of extraneous matter. Vidicon tubes were adapted for non-film equipment. (F.S.)

**247** USE OF FAST NEUTRONS IN DEFECT DETECTION IN MANUFACTURED COMPONENTS. Gorbunov, V. I.; Pekarskii, G. Sh. Defektoskopiya, No. 3, 19-21(1966). (In Russian).

Defect detection in a 300-mm plastic mass behind a 50- to 100 mm lead shield was achieved using fast neutrons from a Po–Be neutron source. With the signal/noise ratio equal to 2, a 300-mm collimater aperture, and 0.7-MeV detector discrimination threshold the sensitivity for defect detection was 3% of thickness. (R.V.J.)

**248** USE OF SCATTERED γ RADIATION IN DEFECTOSCOPY AND MATERIAL THICKNESS MEASUREMENTS. Kodyukov, V. M.; Ostretsov, L. A.; Serebrennikov, I. Ya.; Fradkin, G. M. Defektoskopiya, No. 3, 3-8 (1966). (In Russian).

A method is suggested for separating scattered and nonscattered γ radiation used in defectoscopy and in measuring thicknesses of materials. (R.V.J.)

**249** GAMMA DEFECTOSCOPY SPECTROMETRIC METHOD. Kodyukov, V. M.; Ostretsov, L. A.; Serebrennikov, I. Ya.; Fradkin, G. M. Defektoskopiya, No. 3, 9-12(1966). (In Russian).

A method for using nuclear spectrometry in defect detection, based on the strongest γ quantum and measurements in narrow-beam geometry, is given. (R.V.J.)

## Protective Structures

*Refer also to abstract 98.*

**250** (AD–629633) SHELTER PACKAGE VENTILATION KIT. Final Report. Libovicz, Basil; Behls, Herman F. (General American Transportation Corp., Niles, Ill. General American Research Div.). Oct. 1965. Contract OCD-PS-64-22. 111p. (GARD–1244). CFSTI $4.00 cy, $0.75 mn.

A portable ventilation system that can be driven manually or by an electric motor was developed for use in Civil Defense fallout shelters. This package ventilation kit includes a fan assembly and drive modules which can be assembled and operated by untrained personnel. (auth)

**251** (AD–629634) SHELTER PACKAGE VENTILATION KIT. Summary Research Report. (General American Transportation Corp., Niles, Ill. General American Research Div.). Oct. 1965. Contract OCD-PS-64-22. 18p. (GARD–1244). CFSTI $1.00 cy, $0.50 mn.

Certain fallout shelters in the United States require ventilation systems capable of supplying from 5 to about 30 cubic feet per minute of outside air per person sheltered in order to achieve a high confidence of maintaining tolerable conditions of temperature and humidity during hot weather. The goals of this development program are portability, low cost, manual and electric drive, ease and universality of application. The resulting Package Ventilation Kit (PVK) is a complete packaged mechanical ventilation system that is portable, can be assembled and deployed by untrained personnel, and can be driven either electrically or by human power. The PVK consists of two basic packages—a fan assembly and drive module. (auth)

**252** (AD–634468) AIR BLAST EFFECTS ON UNDERGROUND STRUCTURES. Newmark, N. M.; Sinnamon, G. K. (Illinois Univ., Urbana). Jan. 1954. Contract DA-49-129-eng-239. 134p. CFSTI $13.60 cy, $1.00 mn.

Results of a test to determine the nature of forces transmitted through earth to buried structures from the explosion in air of an atomic bomb are described. The structures were primarily reinforced concrete boxes having a large number of simply supported steel beam strips forming their roofs. Three structures were included in the program and each of the structures had a number of individual beam strips, with several strips of each of three different degrees of flexibility to provide information concerning the effect of flexibility of the structure on the loading transmitted to it. All of the beam strips had the same span, namely 8 ft. The structures were tested in two shots,

the first producing an overpressure level of about 15 psi, and the second about 63 psi. (auth)

**253** (AD–634691) MATERIALS FOR USE IN MITIGATING BLAST LOADS ON DEEPLY BURIED PROTECTIVE STRUCTURES. Hoff, George C. (Army Engineer Waterways Experiment Station, Vicksburg, Miss.). June 1966. 15p. CFSTI $1.00 cy, $0.50 mn.

The behavior of a buried structure subjected to blast loading must be evaluated on the basis of the loads reaching the structure. Research has shown that the use of a properly designed backpacking material placed around the structure dissipates a portion of the shock energy present in the free field, thereby reducing the magnitude of the forces reaching the structure. The response of the backpacking then and that of the structure are completely interdependent, and the design of one cannot be considered without the design of the other. Based on the results of laboratory research, three materials—a naturally occurring friable aggregate, a foamed plastic, and an insulating concrete—are currently being utilized in a prototype experiment to evaluate their shock-dissipating and stress-transfer characteristics. The results of this experiment along with other factors such as cost, availability, and ease of placement will enlighten the future outlook for backpacking materials placed around buried structures. (auth)

## Radioactive Material Handling

*Refer also to abstract 131.*

**254** (K-D–1926) PROTECTIVE PACKAGES FOR $UF_6$ CONTAINERS. Mallett, Albert J. (Oak Ridge Gaseous Diffusion Plant, Tenn.). Sept. 12, 1966. Contract W-7405-eng-26. 4p. (CONF-661011–2). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From AEC Contractors' Nuclear Materials Management Meeting, Berkeley, Calif.

Protective packaging for bulk shipment of cylinders of unmoderated $UF_6$ at $^{235}U$ enrichments to 4.5% is described. A design for packaging these cylinders was developed consisting of an outer shell fabricated from 18 gage steel and an inner shell of 14 gage steel. The development and use of phenolic resin foams using reinforcing additives such as shredded glass fiber for use as insulation materials is discussed. The foam resists fire to 2200°F, adds structural support, and serves as a shock absorber. Fire and drop tests were made on the units and were considered to be successful. (F.S.)

**255** (ORO–651) URANIUM HEXAFLUORIDE HANDLING PROCEDURES AND CONTAINER CRITERIA. Keller, E. L. (comp. and ed.) (Oak Ridge Operations Office (AEC), Tenn.). 1966. Contracts AT(33-2)-1; W-7405-eng-26. 80p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Routine handling procedures, container design, and utilization criteria for $UF_6$ in the AEC are discussed. Criteria for $UF_6$ weighing, sampling, cylinder filling and emptying, cylinder inspection, cleaning, testing and repairing are described. A brief discussion of the physical and chemical properties of $UF_6$ and safety considerations for its handling are included. (F.S.)

**256** (ORO–3298-2) TRACING OF SPECIAL MATERIAL TRANSPORT IN THE OCEAN AT CAPE KENNEDY. Progress Report. [Purpura, James A.; Thornton, Edward B.] (Florida Univ., Gainesville. Engineering and Industrial Experiment Station). June 1966. Contract AT(40-1)-3298. 32p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The use of fluorescent organic pigments and dyes as a tracer material to simulate the movement of waste products in the ocean at Cape Kennedy is described. The tracer material was mixed with cement and allowed to set. The set tracer was then broken up with a hammer mill having exchangeable screens and variable speed provisions for size contrast of the tracer. The tracer was injected into the ocean to simulate the movement of fissionable material. The average particle velocity was found to be 408 ft/day. The distribution of particles at various positions on the beach is also discussed. (R.C.K.)

**257** THE EFFLUENT PROCESSING STATION AT THE CADARACHE NUCLEAR STUDIES CENTRE, A NEW INDUSTRIAL INSTALLATION OF THE COMMISSARIAT A L'ENERGIE ATOMIQUE. Marcaillou, J. (Centre d'Etudes Nucleaires, Cadarache, France); Roux, J.; Brosky, M. pp 71–88 of STI-PUB-116. (In French).

In the design and construction of the effluent processing station at the Cadarache Nuclear Studies Center account was taken of the different sources of the effluents and of the special requirements imposed by the situation of a large center in an area with limited disposal possibilities, which means that the effluents can only be disposed of after a high degree of decontamination. These requirements led to the construction of a processing installation comprising two entirely separate units giving maximum decontamination and concentration efficiency in their treatment of effluents. One of the units is an evaporation plant, consisting of a main evaporator with mechanical recompression and a finishing evaporator. This unit, which is intended for handling the higher-activity wastes with low mineral content from reactors of the swimming-pool type, can be used for processing accidental effluents having a $\beta\gamma$ activity of around 10 C/$m^3$ and gives a decontamination factor of $10^7$. The complex effluents with a very high content of salts from the Center's various laboratories and installations are decontaminated by co-precipitation and filtration in the other unit, which is a chemical processing plant. The design of this plant is such that the treatments can be adapted to the composition of the effluents, so that in each case the decontamination obtained conforms to the requirements imposed in respect of disposal. In addition to these plants there are two storage units, one of which is a pre-processing unit of 5000 $m^3$ capacity; there are also control and applied research laboratories. A preliminary assessment is made of the operation of the plants and laboratories, and it shows the need for making a strict classification of the effluents on arrival at the pre-processing storage unit in order to ensure maximum decontamination in the plants. An installation for packaging in prefabricated concrete containers is being erected at the chemical processing plant. A similar installation is being designed for the evaporation concentrates. (auth)

**258** DESIGN AND CAPACITY OF A COMBUSTION PLANT FOR RADIOACTIVE WASTES FROM ANIMAL EXPERIMENTS. Meissner, J. (Forschungsinstitut Borstel, Ger.). pp 117-25 of STI-PUB–116.

Test operations on a combustion plant specially designed for animal carcasses and other wastes from animal experiments containing radioactive materials as used in biological research are described. The device is used for intermediate-level wastes and allows the handling of radioactivity from 0.1 to 100 mC/kg animal weight, according to the toxicity and radiation properties of the radionuclides concerned. This range covers roughly all tracer studies and, up to a certain extent, also experiments in radiation biology. The plant can be charged with about 5 kg material (wet weight) per half-hour. The combustion takes place in two steps. As soon as the material is passed from the first to the second phase, a new charge may be put in. To the 20-kw electric furnace with an exchangeable muffle of stainless V2A steel, fresh air, preheated in a counter current, is supplied by a ventilator. By opening two traps, the ashes are transferred into a steel container, and after being cooled down they are collected in polyethylene bags. The waste gases pass a cyclone dust-separating drum which is also connected to the ash container. By then mixing the waste gases with cold fresh air, blown in by way of an extra pipeline, they are cooled down to approximately 80°C. Thereafter, aerosols are filtered out by means of two glass filters, one rough and one fine. The exhaust gases then pass

into a turbulence chamber, where they are mixed with the waste air from the air-conditioned laboratories. Before they are blown out of the chimney, the radioactivity is controlled by a large area counter and registered continuously. Details are given of the combustion of rabbit cadavers containing a defined amount of $^{32}P$. The radioactivity of ashes and filter residues are determined separately. In addition, the contamination of muffle and pipelines is controlled. Furthermore, methods are described for handling other materials such as fluids (urine), faeces and experimental wastes. The plant is unsuitable for retaining pure gases like $CO_2$ since a chemical separation is not provided for. Nonetheless, it is still convenient for materials that contain $^{14}C$ within the range of radioactivity as worked within laboratory routine. Finally, capital and operating costs of the plant are discussed. (auth)

**259** SAFETY ASPECTS OF LIQUID RADIOACTIVE WASTE-COLLECTING AND PROCESSING SYSTEMS. **Pott, F. Ph. (Technischer Uberwachungs-Verein Rheinland E. V., Cologne). pp 163-72 of STI-PUB-116.**

Large amounts of liquid radioactive wastes are collected and processed or stored in connection with the operation of nuclear reactors, the handling and processing of fissile materials or radioactive isotopes and the operation of electron and particle accelerators. The safety aspects of such systems including their design, construction and operation are discussed. Our experience gained in this work is described. To decide on the necessary engineering safeguards a classification of the liquid radioactive waste was made according to its radioactive contamination. Based on the maximum permissible concentration (MPC) of water, liquid radioactive waste was divided into the following three categories: category 1: low level: $(10^{-1}-10^{2}) \times$ MPC, category 2: intermediate level: $(10^{2}-10^{4}) \times$ MPC, and category 3: high level: larger than $10^{4} \times$ MPC. The design criteria for collecting and processing equipment such as collection tanks, clean-up filters, demineralizers, piping, etc., are discussed from the safety aspects. The main objectives of the criteria are to prevent leakage and the subsequent contamination of personnel and ground water, radiation hazards from direct radiation, mal-operation and subsequent discharges of liquid waste with unpermitted activity concentration into normal water-discharge canals. Finally, the supervision during the construction, the pre-operational tests, and the repetition tests of such systems are described. (auth)

**260** TREATMENT PRACTICES OF LOW- AND INTERMEDIATE-LEVEL RADIOACTIVE WASTES AT THE JAPAN ATOMIC ENERGY RESEARCH INSTITUTE. **Sugimoto, Sen-ichi; Ishihara, Takehiko (Tokyo Research Establishment). pp 207-22 of STI-PUB-116.**

The radioactive waste treatment plant, at the JAERI Tokai Research Establishment, has operated since 1958, and various contaminated wastes that have been discharged by research laboratories, radioisotope processing facilities, and the five reactors at the Tokai site, have been processed and removed. Most liquid wastes are intermediate-, low-, and extremely low-level. Extremely low-level ($<10^{-6}$ $\mu$C/ml) liquid is discharged after dilution with ordinary effluent. Low-level liquid is processed by flocculators, ion-exchange columns with a membrane dialyzer and evaporators, with capacities of 1 $m^3$/h. Intermediate-level liquid is processed by small evaporators installed in a shielded cell. The resulting sludges are solidified with Portland cement into drums and stored in concrete pits. In 1964 3700 $m^3$ of low- and very low-level liquid were produced, the average volume per capita being 14 $m^3$/yr. The average activity removed was 99.7%, and from 1959 to 1964 about 2.1 mC were discharged into the sea after decontamination. Most solid wastes are low-level and are sent to the treatment plant in 20-liter cartons. Combustible wastes are incinerated at the rate of 3 cartons/h, and non-combustible ones are hydraulically compressed into drums with a volume reduction of one-fifth. In 1964, 11,000 cartons were processed by an incinerator or by a baling press, the average quantity per capita being 17 cartons/yr. They were packaged into 200-liter drums and stored in a semi-underground concrete pit. (auth)

**261** EXPERIENCE IN THE EVAPORATION OF RADIOACTIVE LIQUID EFFLUENTS AND THE SOLIDIFICATION OF EVAPORATION SLUDGES AT THE CENTRE D' ETUDES NUCLEAIRES DE FONTENAY-AUX-ROSES ET DE GRENOBLE. **de Robien, E. (CEN, Grenoble, France); Pomarola, J.; Brodsky, M. pp 279-90 of STI-PUB-116. (In French).**

The evaporators used at the radioactive effluent processing stations of the Grenoble and Fontenay-aux-Roses Centres have been in operation since September 1962 and February 1965, respectively. The reasons for selecting the evaporation method are given, reference being made to the regulations governing disposal of liquid effluents. After a comparative description of the characteristics of the two installations, the experience gained in the course of operation is discussed including concentration factors, decontamination factors, precautions taken to avoid corrosion risks, difficulties encountered, and modifications and improvements made. Laboratory studies carried out on the solidification of sludges are described as well as the various stages leading to the completion of the present installations. Finally, an economic assessment is presented. (auth)

**262** EVAPORATION USED AS THE ONLY TREATMENT FACILITY AT A RESEARCH ESTABLISHMENT. **Bjoerkquist, K.-J.; Linder, P.; Linderoth, G.; Lindhe, S. (Aktiebolaget Atomenergi, Studsvik, Sweden). pp 371-80 of STI-PUB-116.**

The operation of the liquid-waste plant at the Swedish research establishment at Studsvik started in 1959. A segregation of the different categories of liquid waste was made and the volumes and activities produced since then have been studied in relation to the anticipated production. The need of a treatment plant has been analyzed taking into account the anticipated activities in the waste and the restrictions concerning the disposal of radioactive wastes. The choice of evaporation as the treatment method used is based on the following considerations: most wastes can be released without treatment; small volumes of any chemical composition that appear in connection with research work should be treated; a wide variety of decontamination factors is desired; and reactor accidents or accidents in test facilities may result in waste with a high radiation level. Since the operation time is expected to be rather short, a simple type of evaporator was chosen—a standard vertical tube evaporator with natural circulation. The design criteria for the evaporator are: evaporation capacity—0.5 $m^3$/h, concentration factor—100:1, decontamination factor—$10^5$, and operation pressure—atmosphere. The evaporator is shielded for the expected radioactivities. The evaporator has been thoroughly tested with a simulated feed and the design data have been obtained. All operation has been tested and the instruments and control system have been checked during even longer operation period. (auth)

**263** OPERATIONAL EXPERIENCE IN THE TREATMENT OF RADIOACTIVE WASTE AT OAK RIDGE NATIONAL LABORATORY AND BROOKHAVEN NATIONAL LABORATORY. **Cowser, K. E. (Oak Ridge National Lab., Tenn.); Lasher, L. C.; Gemmel, L.; Pearsall, S. G. pp 381-401 of STI-PUB-116.**

Management of radioactive liquid and solid wastes (categorized as low-activity level and intermediate-activity level) at the Oak Ridge National Laboratory (ORNL) and the Brookhaven National Laboratory (BNL) are reviewed. Modifications of the original treatment technology have resulted from operational experience and the findings of research studies, and are discussed in terms of their effect on effluent quality and operation cost. Operating experience with the 1330-liter/min process waste-treatment plant at ORNL has demonstrated that plant efficiency exceeds the design specifications of 50% removal of gross radionuclides. The treatment process used by the horizontal flow plant includes a $CaCO_3$ precipitation using lime and soda ash for removing $^{90}Sr$ and the rare earths and the addition of illitic clay for removing $^{137}Cs$. Under normal operating conditions, an average of 80% to 90% of these important radionuclides are removed at a cost of about $0.1/1000

liters. By optimizing the combination of lime, soda ash and clay, it has been demonstrated that the removal of strontium and cesium can be increased to 90% and 92%, respectively. Excess rates of flow through the plant and the occurrence of detergents and complexing agents in the waste increased the suspended solids in the plant effluent and reduced efficiency. To counter decreased efficiencies, 25% of the plant effluent is recycled for additional treatment, a polyelectrolyte was added to improve coagulation, and the treatment plant effluent was routed through a 5.7-million-liter settling basin. Efficient monitoring of the process waste system has resulted in reduced volumes of waste that require treatment (750 liters/min) and reduced amounts of $^{90}Sr$, $^{137}Cs$, and rare earths in the waste ($<3 \times 10^{-5}$ $\mu C$/ml). Intermediate-level liquid waste ($1.4 \times 10^7$ liters/yr, containing 0.26 to 2600 $\mu C$/ml) will be treated by means of a 2300-liters/h evaporator, which was scheduled for operation in 1965. At BNL, low-level liquid wastes and sanitary wastes are combined to receive biological treatment by an Imhoff tank and sand filter. As a result of diligent waste management, the quantity of gross activity in these wastes (average flow of 2200 liters/min) has been reduced to $1 \times 10^{-7}$ $\mu C$/ml. The filter beds are now removing 20% of the radionuclides. An evaporator is used to process intermediate-level wastes that average $1 \times 10^6$ liters/yr and contain 0.004 to 0.2 $\mu C$/ml. A decontamination factor of $10^4$ to $10^6$ and volume reduction of 85 to 100 are now achieved. Previously, 200-liter drums were used to package contaminated solid waste and evaporator concentrate slurried with cement for off-site shipment. As a result of increased volumes of solid waste and excessive external radiation levels, reinforced concrete vaults are now used with walls 15 cm to 43 cm thick for gamma shielding. Waste slurry from the evaporator is now solidified in the vaults with cement and vermiculite to reduce handling and shipping costs and to preserve the integrity of the container. Additional reduction in cost and in exposure to personnel during solid-waste processing is realized by baling contaminated filters, by decontaminating metal objects with shot-blasting, and by dismantling large, grossly contaminated items with shaped charges of high explosives. (auth)

**264** UNITED ARAB REPUBLIC PROGRAMME FOR MANAGEMENT AND TREATMENT OF LOW- AND INTERMEDIATE-LEVEL RADIOACTIVE WASTES. Mahmoud, K. A.; Yousef, Y. A.; El-Reedy, H.; Chafik, A.; (Atomic Energy Establishment, United Arab Republic). pp 411-17 of STI-PUB-116.

Radioisotopes have been used in the U.A.R. since 1955 for research and application in medicine, agriculture and industry. The first research reactor started operation in August 1961. The radioisotope production laboratory was established in the reactor site and had started to produce radioisotopes by January 1963. The amount of radioactive wastes that resulted from radioisotope users, operation and isotope production in the U.A.R.A.E.E. and the different laboratories can be classified as low- to intermediate-level wastes. These wastes are discharged to the environment under controlled conditions. At present there are adequate storage facilities for liquid and solid wastes. In general, radioactive solid waste is stored in concrete-lined drums while liquid waste is discharged into delay tanks. A chemical treatment plant with a capacity of 500 l/h is to be constructed within one year. This plant will handle low- and intermediate-level liquid waste from the establishment as well as other laboratories and hospitals all over the U. A. R. The post-treatment effluent will be discharged to the ground via cribs, or to the sanitary sewer after being checked for radioactivity. The sludges resulting from treatment will be mixed with concrete or incorporated with tar and stored in lined concrete pits. The hydrology of the site and underground water movement have been studied to evaluate any hazard that may result from ground disposal. All measures are taken to prevent hazards arising from the contamination of public facilities such as the Ismailia Canal. (auth)

**265** EXPERIENCE OBTAINED DURING SEVEN YEARS' OPERATION OF THE MOSCOW PLANT FOR THE DECONTAMINATION AND CONCENTRATION OF RADIOACTIVE EFFLUENTS, AND SOME DATA ON THE DECONTAMINATION OF LOW-ACTIVITY WASTE WATERS CONTAINING DETERGENTS. Trofimov, D. I.; Zver'kova, Z. A.; Belokurova, M. A.; Vedishcheva, T. S.; Efimov, A. N.; Kulichenko, M. N.; Odintsova, E. G.; Rauzen, F. V.; Solov'eva, Z. Ya.; Shakhov, E. A. pp 449-75 of STI-PUB-116. (In Russian).

Experience in concentrating and decontaminating wastes is described. The process presented ensures reduction of the level of most isotopes to the maximum permissible concentrations. Concentration and decontamination factors are given. It is shown that the presence of detergents in waste waters does not prevent their decontamination by the process of coagulation and two-stage ion exchange. Moreover, detergents can be removed from the waste waters either by precipitation with calcium salts or by sorption on powdered activated carbon during coagulation and foaming. (auth)

**266** THE TREATMENT OF INTERMEDIATE-LEVEL RADIOACTIVE WASTES BY EVAPORATION: THE DESIGN AND PERFORMANCE OF EVAPORATION SYSTEMS. Clelland, D. W.; Corbet, A. D. W. (United Kingdom Atomic Energy Authority, Risley, Eng.). pp 497-515 of STI-PUB-116.

The design and performance of evaporation plants for the treatment of intermediate-level radioactive liquid wastes is described. The data used are based upon design, development and operational experience of the United Kingdom Atomic Energy Authority. These data and experience have been applied to the solution of a typical intermediate-level waste problem. A number of solutions are considered and various alternative plant designs are presented. The performances of these alternative systems are evaluated and discussed. In the examination of various evaporation schemes it is shown that the performance in terms of overall activity decontamination can be greatly affected by the choice of a route for the process liquors within the system. The means of achieving a high performance in this respect are discussed in detail. The selection of process conditions to avoid excessive entrainment and corrosive conditions is discussed and methods of avoiding violent organic/acid reactions are described. In the alternative designs presented, multi-effect evaporation is examined as a means of achieving steam economy, and the use of an integral evaporator and storage tank is also assessed. All the alternative systems considered are suitable for design to the appropriate standards required for the activity level involved. Since the recovery of nitric acid is often associated with such processes, allowance has been made in all the alternative designs for the incorporation of acid recovery plant should this be appropriate. It is intended that this study be of value generally in the assessment of possible alternative solutions to waste-treatment problems. (auth)

**267** OPERATION OF THE STATION FOR TREATING RADIOACTIVE WASTES AT MOL. Van de Voorde, N.; Hoffmann, E. (Centre d'Etude de l'Energie Nucleaire, Mol, Belg.). pp 527-68 of STI-PUB-116. (In French).

The Belgian Nuclear Research Center (C.E.N.) is located in a rather densely populated area. Waste disposal into the river and the storage possibilities are extremely limited because the river Molse Nethe is too small and the sandy sub-soil is considered as a source for drinking water. Besides, soil retention appears to be rather low. A ministerial regulation states that the disposal into the river of aqueous radioactive waste must be controlled to such an extent that drinking water tolerance is respected. Therefore, river water concentration, after dilution, must be below $10^{-6}$ $\mu C/cm^3$. During the treatment of radioactive waste it was necessary to pay special attention to the collection system actually developed so far because the active waste separation already takes place where these residues are produced. Next, the waste must be conveyed to the processing plant either through special pipes or under standardized packing. The administrative set-up which regulates this collecting system allows an easy and exhaustive inven-

tory of the stored radioactive materials, as well as the determination of reduction and decontamination factors at any step during the processing stage. On the other hand, the processing itself must be specific for each type of waste dealt with separately. For cold and warm liquid waste processing, co-precipitation and ion exchange techniques are mostly applied to continuous or batch treatment, resulting in a total decontamination of 99.9%. The presence of complexing agents and detergents produces interferences that can be overcome by using suitably adapted techniques and reagents. The ultimate insolubilization and storage of radioactive concentrates were specially emphasized. By homogeneous dispersion of filtered precipitates into hot asphalt (240°C), a stabilized mixture containing 40% radioactive material is obtained. The leaching rate tested with ground and sea water is kept below $10^{-6}$ g/cm$^2$d. Such a process corresponds to a total concentration factor of around 3000. After a preliminary selective sorting of combustible and non-combustible wastes, residues undergo different processes according to their respective category, i.e., size-reducing, baling or incinerating them before ultimate insolubilization with asphalt. Those specific operations require a plant thoroughly equipped with cutting and baling devices, an incinerator provided with off-gas scrubbing, and with a maximum incinerating capacity of 200 kg/h, leading to a total concentration factor of 90. Various decontamination techniques such as degreasing, steam and abrasive blasting, melting, etc., permit the recovery of valuable and useful equipment or instruments. Moreover, contaminated clothing is decontaminated and washed in a special laundry before being returned to the respective users. The radioactive waste processing plant was run at Mol on an industrial scale and, simultaneously, a detailed cost calculation system was set up. (auth)

**268** INSOLUBILIZATION OF RADIOACTIVE CONCENTRATES BY INCORPORATION INTO BITUMEN. Van de Voorde, N.; Dejonghe, P. (Centre d'Etude de l'Energie Nucleaire, Mol, Belg.). pp 569-600 of STI-PUB-116. (In French).

Most plants dealing with radioactive waste processing aim at the maximum separation and concentration of the waste radioactivity into the smallest possible volume. These concentrates tend to be dissolved when brought into contact with ground or sea water, so that insolubilization is necessary in order to eliminate this possibility. The feasibility of incorporating radioactive sludges and ashes into bitumen material, up to 50% by weight is demonstrated. The resulting bitumen mixtures indicate an insignificant elution of the present radioisotopes ($10^{-6}$ g/cm$^2$d) and show no damage when irradiated up to $10^9$ rad. Different types of bitumen insolubilizators are now in operation on an industrial scale; they are specially designed for the insolubilization, at high temperatures, of chemical sludges that result from treating radioactive liquid effluents, and also for the incorporation of incinerator ashes. Even evaporator concentrates containing no hygroscopic salts can be easily evaporated to dryness in bitumen. Non-condensable off-gases undergo scrubbing and electrostatic filtration before they are released into the atmosphere. The homogeneous mixtures are finally collected in steel drums for storage below ground or dumping into the sea. (auth)

**269** TREATMENT OF LOW-LEVEL SOLID WASTES AT THE ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL. Burns, R. H.; Clare, G. W.; Smith, A. J.; Dunkason, D. A. (Atomic Energy Research Establishment, Harwell, Eng.). pp 639-61 of STI-PUB-116.

Incineration has been used at A.E.R.E., Harwell, for over 10 yr and has proved to be a satisfactory method of volume reduction for combustible waste. Past experience has been reported on a number of occasions and is not referred to here in any great detail. However, now in operation is a small-scale incinerator which has been designed and erected to enable a better appreciation of the problems of incineration to be obtained and to produce a small, relatively inexpensive plant which is adequate for low-level waste. Details of this equipment, together with the results obtained to date, are given. A new handling and sorting area for low-level wastes has been commissioned this year. It has been shown to be advantageous for the operators to wear pressurized suits, which give increased output as compared with glove-box sorting. The Sealed Area contains a sorting bench, glass crusher, plastic shredder and a large 83-t baling press. Practical experiences in operating this area and the results obtained are given. Comparative costs between various methods of handling low-level solid wastes from A.E.R.E., Harwell, are detailed. (auth)

**270** FIXATION OF RADIOACTIVE WASTES IN CEMENT. Nazarova, A. I.; Kulichenko, V. V.; Dukhovich, F. S.; Volkova, O. I.; Boyarinova, M. V.; Sobolev, I. A.; Khomchik, L. M.; Bazhenov, Yu. M. pp 779-89 of STI-PUB-116. (In Russian).

A study of the leaching of the most dangerous radioelements, $^{90}$Sr and $^{137}$Cs, is discussed. It was shown that, regardless of the type of waste, $^{137}$Cs and $^{90}$Sr have high elution values, i.e., (2 to 12) $\times 10^{-2}$ and (2 to 6) $\times 10^{-2}$ g/cm$^2$/24 hr, respectively. In the light of these findings, recommendations concerning maximum concentrations of solutions for combination with cement are made. Data are also given for gas evolution in radioactive cements. Work on the cementing of liquid wastes with activities of $10^{-4}$ to $10^{-6}$ C and on the burial of radioactive cements combined with dry wastes is also reported. The solution/concrete ratio was 0.75. Use of the combined method of burial reduces the cost of liquid-waste storage per cubic meter by 40–50%. (auth)

**271** THE LATEST RESEARCH AND ADVANCES IN THE TREATMENT OF LOW- AND INTERMEDIATE-LEVEL RADIOACTIVE WASTES IN BULGARIA, HUNGARY, THE USSR, AND CZECHOSLOVAKIA. Balukova, V. D.; Kuliuenko, V. V.; Nazarov, A. I.; Sibirev, A. V.; Rauzen, F. V. pp 841-67 of STI-PUB-116. (In Russian).

Data on waste water coagulation and detergent decontamination are presented. Results of investigations into ion-exchange methods of decontamination, extradialysis and concentration by evaporation are discussed. Data are given for various methods of solidifying radioactive wastes, e.g., vitrification, cementing, and the preparation of ceramic blocks. Data resulting from the incineration of wastes in experimental furnaces are given. Included is a short account of waste treatment work in Bulgaria, Hungary and Czechoslovakia. (auth)

# INSTRUMENTATION

## Radiation Detection Instruments

*Refer also to abstracts 34 and 997.*

**272** (AD-631930) DESIGN, CONSTRUCTION, AND OPERATION OF THE 50 CENTIMETER LIQUID HELIUM BUBBLE CHAMBER. Interim Technical Report, 1965-1966. Block, Martin M.; Walker, Ronald J. (Northwestern Univ., Evanston, Ill.). Apr. 28, 1966. Contract Nonr-1228(21). 41p. (TR-1-66). CFSTI $2.00 cy, $0.50 mn.

The chamber, whose dimensions are 50 × 25 × 30 cu cm, is operated in the magnetic field whose maximum value is approximately 28 kilogauss. The photography is of the dark-field type using straight-through illumination from a diffusing screen with dark patches. A pair of condensers, located close to the chamber, form images of the dark patches about the 3 camera lenses, which view the chamber with 16 degree stereo. New cameras have been installed which use 35 mm sprocketed film, and these cameras can advance in 0.1 seconds. The chamber has completed a successful run producing 400,000 triads in a 150 MeV/e pion beam at the University of Chicago synchrocyclotron. It requires a crew of three and can be lifted into the beam in an operational condition. The static loss rates from the liquid helium reservoir are around 2 liters/hour and the dynamic loss is about 1 liter per 400 expansions. (auth)

**273** (CISE-101) AN EQUIVALENT CIRCUIT FOR THE STATISTICAL BEHAVIOR OF THE SCINTILLATION COUNTER. Donati, S.; Gatti, E.; Svelto, V. (Centro Informazioni Studi Esperienze, Milan (Italy)). May 1966. 26p. Dep. mn.

An exact solution for the statistical behavior of the scintillation counter is given, considering time dependent branching processes. A statistical equivalent circuit was obtained for the phototube useful for determining the accuracy of energy and time measurement. (auth)

**274** (JINR-P-2851) KORREKTSIYA AMPLITUDNYKH SPEKTROV S POMOSHCH'YU TSVM. (Correction of Pulse Height Spectra With the Help of Digital Computers). Zabiyakin, G. I.; Prikhod'ko, V. I.; Tishin, V. G.; Chelnokov, L. P. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1966. 10p. Dep. mn.

A method of correction of pulse height spectra with the help of digital computers is described. (auth)

**275** (JINR-P-2889) VOSSTANOVLENIE PROSTRANSTVENNYKH KOORDINAT TOCHEK TREKOV PO DVUM STEREOPROEKTSIYAM. (Space Coordinate Reconstruction of Track Points by Two Stereoprojections). Ivanchenko, I. M.; Krutkova, N. A.; Moroz, V. I.; Ostanevich, T. G.; Tentyukova, G. N. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1966. 16p. Dep. mn.

By the least squares method the formulas were obtained of space coordinate reconstruction of points by two stereoprojections for the case of photography with the parallel axis cameras. The formulas obtained result in much smaller dispersions of space coordinates of the corresponding points, especially for the regions near to stereobasis. The formulas described were successively used in a number of programs of a geometrical reconstruction, worked out in the JINR. (auth)

**276** (JUEL-377-PC) DIE ZAEHLUNG VON $^{147}$Pm MIT HILFE EINES FLUESSIG-SZINTILLATIONSDETEKTORS UNTER ANWENDUNG DER KANALVERHAELTNISMETHODE ZUR KORREKTUR VON LOESCHEFFEKTEN. (The Counting of $^{147}$Pm With the Help of a Liquid Scintillation Detector by Use of the Channel Ratio Method of the Correction of Quenching Effect). Blair, A. F.; Murrenhoff, A. P. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Physikalische Chemie). Apr. 1966. 22p. Dep. mn.

A liquid scintillation method for the counting of $^{147}$Pm was developed. The method is especially suitable for the measurement of samples which have a high concentration of inactive materials. In all counting methods which require a processing of the sample to a counting plate, difficulties occurred in the measurement of $^{147}$Pm samples with high concentrations of inactive materials as a result of the self absorption of the soft $\beta$ radiation in the preparation. Adequate time constancy and reproducibility of the measurements were obtained by the addition of tri-n-octylphosphine oxide to the scintillator. This admixture prevents wall adsorption and the precipitation of the Pm from the scintillator solution without exerting a significant solubility effect on the scintillator. A stabilizing effect was observed with the addition of concentrated lithium nitrate solution to the scintillator, but additions of this type have a significant solubility effect. (tr-auth)

**277** (SLF-A5) AN ALGOL PROGRAMME FOR THE DETECTION EFFICIENCIES AROUND A CYLINDRICAL SCINTILLATION CRYSTAL. Castren, O. (Institute of Radiation Physics, Helsinki (Finland)). Sept. 1966. 17p. Dep. mn.

A computer program is presented by which it is possible to study the distribution of the detection efficiency around a cylindrical scintillation crystal and to calculate detection efficiencies of large volume samples. The program takes into account attenuation in the sample, crystal shield and the wall of the sample container. It was written specifically for a sample container surrounding the crystal, an arrangement generally used in the measurement of environmental samples in health physics. In addition to the complete program, the general mathematical principles and detailed explanations of the program are presented. The program was written for an Elliott 503 computer equipped with a core backing store. (auth)

**278** (UCRL-16931) FLUCTUATIONS OF ENERGY LOSS BY HEAVY CHARGED PARTICLES IN MATTER. Maccabee, Howard David (Lawrence Radiation Lab., Univ. of California, Berkeley). July 20, 1966. Contract W-7405-eng-48. 120p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

Thesis.

Significant fluctuations of energy loss are expected in certain cases of the passage of fast heavy charged particles through thin absorbers. When the number of particle-electron collisions in the upper collision-loss interval is small, the energy-loss distribution is asymmetric and is characterized by a broad peak around the most probable energy loss (which is significantly less than the mean energy loss) and by a high-energy-loss tail. Several theories predict the energy-loss distribution function, but previous experimental work is incomplete with respect to verification of theory over the whole significant range of the parameters involved. Beams of 730- and 45-MeV protons, 910-MeV helium ions, and 370-MeV $\pi$-mesons were passed through silicon semiconductor detectors of varying thicknesses, and measured the resulting energy-loss distributions. Within the limits of experimental error, there is very good agreement between the measured energy-loss distributions and those predicted by the theory of Vavilov, and good agreement on the value of the most probable energy loss. The results are tabulated and their physical and biological implications discussed. (auth)

**279** A MAGNETIC FIELD WITH A SYMMETRY OF REVOLUTION THAT DECREASES WITH THE INVERSE OF THE DISTANCE TO THE AXIS, USING TRUNCATED CONICAL COILS. Mugnier, Daniel; Joseph, Jacques; Lafoucriere, Joseph (Univ., Lyon). Compt. Rend., Ser. B, 263: 576-9(Aug. 22, 1966). (In French).

Using conical coils of infinite length, a magnetic field is obtained with a symmetry of revolution according to $r^{-1}$, which is theoretically perfect. A method for the practical

realization of this topography is proposed, either by using truncated conical coils, or using continuous copper sheets in the same geometry. Corrective coils can compensate for the effects of the finite edges or for the regions near the vertex. A field is thus obtained, which follows an $r^{-1}$ law in a domain $(r_i, r_s)$ such that $r_s/r_i = 6.5$ with a precision of $2.2 \times 10^{-4}$. A $\beta$ spectrometer with trochoidal trajectories, constructed according to this method, would have a total aperture in the plane of symmetry of 180° on the median tangential plane, and would thus have very excellent transmission. (tr-auth)

**280** USE OF SURFACE BARRIER DETECTORS FOR NEUTRON DETECTION. Rao, E. V. R. (Atomic Energy Establishment, Trombay, India). Indian J. Pure Appl. Phys., 4: 340-3(Sept. 1966).

Details of the procedure for fabricating surface barrier semiconductors using n-type silicon crystals are given and their characteristics analyzed. The suitability of these detectors for detecting neutrons was tested by studying the resolving power of the detectors in the case of fission products, $\alpha$ particles, etc., using $U_{92}^{235} + n_0^1 \rightarrow U_{92}^{236}$ and $Li_3^6 + n_0^1 \rightarrow He_2^4 + H_1^3 + 4.78$ Mev reactions. The potentialities of the surface barrier detectors in $\alpha$-ray spectrometry and for detecting neutrons as well as heavy ions are indicated. (auth)

**281** PREPARATION AND USE OF Ge (Li) GAMMA DETECTORS. Nurmia, Matti (Univ. of Helsinki); Stubb, Tor. Ann. Acad. Sci. Fenn., Ser. A VI, No. 213, 1-10 (1966).

Techniques used in the preparation of lithium-drifted germanium detectors are described. The lithium drifting process is controlled with a thermoelectric heating and cooling module. The method has yielded detectors with a thickness of up to 2.5 mm and a resolution limited by the preamplifier noise (under 5 kev FWHM). For $\gamma$ spectroscopy the detectors are mounted in special liquid-air cryostats which require a refill every five days only. (auth)

**282** LOWER LIMIT OF DETECTION FOR SHORT-LIVED RADIOISOTOPES. Sterlinski, Slawomir (Inst. of Nuclear Research, Warsaw). Nukleonika, 11: 441-53 (1966).

The relation of the "lower limit of detection" for short-lived radioisotopes and the measurement time and the so-called "merit of the detector" was studied. It was found that the limit of detection reaches a minimum for the measurement time 1.81 $T_{½}$ (if the condition $\sqrt{k_B} \gg 1$, where $k_B$ is the observed number of counts of background, is fulfilled). The numerical value of the "lower limit of detection" can be calculated according to the included formulas. The theoretical conclusions are illustrated by two experiments using the radioisotopes $^{66}Cu$ ($T_{½}$ = 5.1 min) and $^{52}V$ ($T_{½}$ = 3.75 min). (auth)

**283** CORRELATION METHOD FOR MEASURING ENERGY SPECTRA OF NUCLEAR PARTICLES BY TIME OF FLIGHT. Mogilner, A. I.; Salnikov, O. A.; Timokhin, L. A. Prib. Tekh. Eksp., No. 2, 22-7(Mar.-Apr. 1966). (In Russian).

A correlation method was suggested for measuring energy spectra of nuclear particles. An analysis is made of the statistical accuracy of the measurements and of the apparatus. (R.V.J.)

**284** TIME GATE DESIGN FOR EXPERIMENTS WITH MUONS. Basiladze, S. G. (Joint Inst. for Nuclear Research, Dubna, USSR). Prib. Tekh. Eksp., No. 2, 78-81 (Mar.-Apr. 1966). (In Russian).

A transistorized muon time gate device was designed with time gate delay range $T_d$ = 0.4 to 2.8 $\mu$sec, time gate formation time $T_t$ = 0.6 to 3.0 $\mu$sec and a scheme for blocking mesons of double momenta. (tr-auth)

**285** NEUTRON SPECTROMETER BASED ON X-RAY GONIOMETER GUR-3. Vintaikin, E. Z.; Gorbachev, V. V. Prib. Tekh. Eksp., No. 2, 197-8(Mar.-Apr. 1966). (In Russian).

A schematic design of a neutron spectrometer with an x-ray goniometer GUR-3 is presented. This model spectrometer eliminates the strong connection between the counter and the shielding. An adjustment on the shielding allows a 1 to 2° horizontal movement of the spectrometer. Its light weight permits easy adjustment to various incidence and scattering angles. (G.O.Y.)

**286** SPARK COUNTER. Akopyan, G. S.; Marikyan, G. A.; Matevosyan, K. A. Prib. Tekh. Eksp., No. 2, 199-200(Mar.–Apr. 1966). (In Russian).

The construction and performance of a spark chamber with aluminum-coated glass electrodes are described. The charged-particle trajectories are recorded through the 0.1 mm gaps formed by the sparks produced by the charged particle passage. It was found that counter electrodes made of thick aluminum sheets produced the same effect as the aluminum coatings only a few microns thick. Two hundred events were recorded, and the efficiency of the counter is discussed on the basis of these events. (G.O.Y.)

**287** MEASUREMENTS OF THE ANGULAR DISTRIBUTION OF FISSION FRAGMENTS. Klyucharev, A. P.; Ranyuk, Yu. N.; Rutkevich, N. Ya.; Khalin, N. F. (Inst. of Physics and Tech., Kharkov). Prib. Tekh. Eksp., No. 2, 201-2(Mar.-Apr. 1966). (In Russian).

A cylindrical glass detector was used to measure the angular distribution of fission fragments. The irradiated glass was checked with a standard microscope that had been fitted with a movable adjustor to hold the cylindrical detector. The angular distribution of fragments from lead photofission at a maximum energy of 250 MeV and of fragments of $^{235}U$ fission by 20-MeV protons was obtained using this detector along with microscope scanning. (G.O.Y.)

**288** BUBBLE CHAMBERS WITH 100 kOe PULSED MAGNETIC FIELD IN 8 LITER VOLUME. Makarin, V. K.; Martemyanov, V. P. (Inst. of Nuclear Energy, Moscow). Prib. Tekh. Eksp., No. 2, 147-51(Mar.-Apr. 1966). (In Russian).

A bubble chamber with a 100-kOe pulsed magnetic field, used in elementary particles work, is described. The strength of the magnetic field was $\overline{H}$ = 65 kOe for a 12 l volume, and $\overline{H}$ = 100 kOe for an 8 l volume. The pulse time was ~2 msec. (G.O.Y.)

**289** PLANE SLOW NEUTRON DETECTOR. Vedekhin, A. F. (All-Union Scientific-Research Inst. of Geophysics, October City, USSR). Prib. Tekh. Eksp., No. 2, 76-7(Mar.-Apr. 1966). (In Russian).

A plane slow neutron detector equipped with T-1 and T-2 phosphors is described. The detector disc was prepared from a plastic with side window gaps in the shape of a parallel line grid or of coaxial circles. The phosphor was coupled to the plastic glass by a solution of dichloroethane. The slow neutron detector efficiency varies with the number of gaps, their width, and depth. (tr-auth)

**290** SCINTILLATION TYPE MASS SPECTROMETRIC ION DETECTOR. Kolchin, A. M.; Kolesnikov, B. Ya. (Moscow State Univ.). Prib. Tekh. Eksp., No. 2, 99-101(Mar.-Apr. 1966). (In Russian).

Description is given of a high sensitivity scintillation type spectrometric ion detector capable of measuring ion current and direct current with higher sensitivity than ordinary electrometric systems. The detector is capable of rapid change from measuring ion current with scintillation channel to electrometric systems and vice versa. (tr-auth)

**291** GAS-FILLED COUNTER WITH QUARTZ WALLS. Karasik, A. S. (Perm State Univ., USSR). Prib. Tekh. Eksp., No. 2, 68-70(Mar.-Apr. 1966). (In Russian).

Descriptions are given of the construction and specifications of a $CO_2$ filled counter with quartz walls transparent to ultraviolet radiation discharge. The counter was filled with $CO_2$ with quenching additions of cyclohexane. At $CO_2$ pressure over 300 torr and cyclohexane 20 torr the counter plateau was found at 400 to 600 v and ~0.5% incline per 100 v. (tr-auth)

**292** CHERENKOV DIFFERENTIAL GAS COUNTER. Klebanov, Yu. D.; Kruchinin, S. P.; Lozina, L. A. (Inst.

of Nuclear Energy, Moscow). Prib. Tekh. Eksp., No. 2, 66-7(Mar.-Apr. 1966). (In Russian).

The construction and tests carried out with a gaseous differential Cherenkov counter designed for operation with a hodoscopic device in a bubble chamber are described. The resolving power of the counter was $\Delta\beta/\beta = 2 \times 10^{-3}$ and the efficiency 0.96 ± 0.02. (tr-auth)

**293** IONIZATION CHAMBER FOR RECORDING FISSION FRAGMENTS IN HIGH ALPHA-ACTIVITY BACKGROUND. Nasyrov, F.; Pashkin, N. F. Prib. Tekh. Eksp., No. 2, 64-5(Mar.-Apr. 1966). (In Russian).

Descriptions are given of a pulsed ionization chamber having a pulse rise time of ~25 nsec, for recording fission fragments. The chamber filled with fissioning material with total $\alpha$ activity up to $8 \times 10^7$ sec$^{-1}$ performed efficiently. (tr-auth)

**294** OPTICAL CHARACTERISTICS OF SEMICONDUCTOR DETECTORS FOR NUCLEAR PARTICLES AND THEIR SURFACE PHENOMENA. Akimov, Yu. K.; Wang, Chien-wa; Sidorov, A. I.; Epshtein, M. I. (Joint Inst. for Nuclear Research, Dubna, USSR). Prib. Tekh. Eksp., No. 2, 60-3(Mar.-Apr. 1966). (In Russian).

The effective quantum yield $\eta$ of thick silicon nuclear particle detectors illuminated from the end window was studied. A reduced $\eta$ related to the surface recombinations was observed in the short-wave region. In some cases at the $\lambda$ = 800 to 1000 nm range the quantum yield is close to unity. The instrument can be used as a low inertia counter for incident quanta at a wide range of light signal amplitudes. (tr-auth)

**295** HIGH-IMPEDANCE SILICON SEMICONDUCTOR COUNTERS FOR CHARGED PARTICLES. Maksimov, Yu. S.; Rodionov, Yu. F.; Yavlinskii, Yu. N. (Inst. of Nuclear Energy, Moscow). Prib. Tekh. Eksp., No. 2, 55-9(Mar.-Apr. 1966). (In Russian).

A simple method is given for preparing high-impedance n-type silicon barrier counter for charged particles. Brief description is given of the recording mechanism and characteristics of a semiconductor $\alpha$ spectrometer for measuring the isotopic content of various $\alpha$ radioactive materials. An alpha spectrometer consisting of a semiconductor detector with ~20 mm$^2$ working area and instrumentation of $\Delta E_\alpha/E_\alpha = 0.3\%$ resolving power for $\alpha$ particles with $E_\alpha$ = 6.1 MeV is described. The device drift did not exceed 2 KeV/hr. (tr-auth)

**296** SEMI-AUTOMATIC MIGE-2 MICROSCOPE FOR MEASURING GEOMETRIC PARTICLE TRACK PARAMETERS IN NUCLEAR EMULSIONS. Raguzin, R. M.; Sharygin, N. V.; Fedorova, N. M. (Leningrad Joint Optical-Mechanical Plants). Prib. Tekh. Eksp., No. 2, 51-5(Mar.-Apr. 1966). (In Russian).

A semi-automatic device for determining and recording X, Y, and Z coordinates is described. Further determination of geometric parameters was carried out with the universal computing machines according to the preliminary design program using group numbers in the computer. The precision of the X and Y coordinate determination is 0.005 and 0.0001 mm and 0.001 and 0.0002 mm for Z, depending on the method of determination on the table or in the microscope field. The plate dimensions ranged from 60 × 40 to 120 × 220 mm$^2$. (tr-auth)

**297** GAS MIXTURES FOR SPARK CHAMBERS. Golubnichii, P. I.; Yakovlev, V. I. (Inst. of Physics, Moscow). Prib. Tekh. Eksp., No. 2, 49-50(Mar.-Apr. 1966). (In Russian).

Mixtures of He + Xe, He + Ar, and Ar + Xe were tested in a 25 × 50 cm$^2$ spark chamber with spark interval varying from 0 to 10 cm. Computing characteristics of each mixture were checked and high-voltage pulse amplitude was determined for recording efficiency of single cosmic particles. It was found that voltage breakdown in Ar and Xe is higher than in He. Additions of Ar to the Ar–Xe mixture reduced the breakdown potential of the mixture. Further studies with Ne and He mixtures showed that from the economical point of view spark chambers filled with 75% Ne and 25% He are the most efficient. However, further investigations are necessary in order to determine the efficiency of the mixture for simultaneous recording of charged particle showers. (R.V.J.)

**298** LARGE MEMORY STORAGE SPARK CHAMBERS. Daion, M. I.; Klimanova, L. F.; Knyazev, V. M.; Krylov, S. A. (Inst. of Physics, Moscow). Prib. Tekh. Eksp., No. 2, 45-8(Mar.-Apr. 1966). (In Russian).

The basic characteristics are given of an air-argon chamber with a dielectric. The efficiency, memory time, precision of trajectory localization, and shower efficiency are analyzed. It is shown that the spark shift from the trajectory is from ~0.3 mm to ~400 $\mu$sec with the trajectory angle dip from 0 to 25° in the direction of the electric field. A drop in particle recording efficiency as a function of the time delay and the number of particles passing through the chamber was observed. (R.V.J.)

**299** DEPENDENCE OF GAMMA-SPECTROMETER RESOLUTION ON THE VARIATION OF PHOTOCATHODE SENSITIVITY AND SELECTION OF FEU-43 SPECTROMETER PERFORMANCE. Belle, Yu. S.; Shchedrin, D. A.; Zlobin, L. I. (Scientific Research Inst. of Radiation Protection, Leningrad). Prib. Tekh. Eksp., No. 2, 41-3(Mar.-Apr. 1966). (In Russian).

An adjustment was designed for measuring the distribution of various elementary zones in a FEU-43 photocathode according to their sensitivity and the influence of this distribution on the $\gamma$ spectrometer performance and sensitivity. The sensitivity of the photocathode was tested with a 2.0 mm and 0.2 mm thick CsI(Tl) crystal irradiated with $^{239}$Pu $\alpha$ particles. The source produced a peak with 4.5 to 5.0% resolution and high stability for long time. Tabulated data are given of the comparative photo-peak resolutions of $^{137}$Cs obtained in 70 × 70 mm$^2$ NaI(Tl) crystal and different photoelectron multiplier tuning. (R.V.J.)

**300** CYLINDRICAL CHARGED PARTICLE ENERGY SPECTROMETER WITH MOVEABLE OBJECTIVE. Shapovalov, A. S.; Kozlov, I. G. (Saratov State Univ., USSR). Prib. Tekh. Eksp., No. 2, 34-6(Mar.-Apr. 1966). (In Russian).

Construction characteristics are given for a spectrometer designed for investigation of electron energy distribution across an electron beam cross section in a device with pressure changes up to $3 \times 10^{-9}$ torr. An electrostatic field of a cylindrical capacitor with an electron flux distributed at a sharp angle to the cylinder axis is used as the analyzing element in the spectrometer. (tr-auth)

**301** APPARATUS FOR RECORDING AN IMAGE OF THE LOCAL DISTRIBUTION AND THE RADIATION INTENSITY OF RADIOACTIVE MATERIALS DEPOSITED IN A SPACE. Ziegler, Albert (to Siemens-Schuckertwerke Aktiengesellschaft). U. S. Patent 3,259,747. July 5, 1966. Priority date Sept. 21, 1962, Germany.

A method and apparatus are described for determining local distribution and intensity of radioactivity deposited in a space, e.g., where radioactive materials are used or in a reactor access area. A photograph is used for the image of the space and is taken from the same point from which the image of the radiation is recorded. The distribution of the radioactive material can then be read directly. The camera used includes a shielded space and sphere. A borehole is open through the sphere to the space from outside the camera. The sphere can be rotated in two ways. Radioactive materials are deposited on the walls of the space and a corresponding film area is darkened. The degree of film darkening is used to determine intensity. (F.S.)

**302** INDUCTIVE LOCATION OF SPARKS IN A SPARK CHAMBER. Poelz, G.; Springer, K. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 1188-92(July 1966). (In German).

A spark chamber is described, for use of particle-path location in a magnetic spectrometer. The spark is localized electronically by inducing pulses in wire windings with coordinate-depending amplitudes. The method was proved in a spark chamber with 15 × 15 cm$^2$ electrodes of stainless

steel meshes, with 13 wires per mm, 0.036 mm thick. A nearly linear slope for the calibration curve was obtained with artificial sparks. Sparks at the same spot gave a pulse-height distribution with a half-width corresponding to 0.2–0.3 mm and a total spread of 0.4–0.7 mm. Results obtained with a $^{144}Ce$ $\beta$ source showed that a similar behavior can be expected for natural sparks. This method renders possible a simple and compact set-up, without any restriction in respect to the material used for the electrodes of the chamber. (auth)

**303** CONTINUOUS SWELLING MEASUREMENTS DURING THE PROCESSING OF NUCLEAR EMULSIONS. [PART I]. Frieser, H.; Heimann, G.; Eger, H. (Technische Hochschule, Munich). Photogr. Korresp., 99: 19-25(1963). (In German).

The swelling changes that a nuclear emulsion undergoes during processing were measured as a function of various development parameters. The experimental techniques and methods used are described. The parameters considered were support weight, penetration of the calipers, temperature changes, and various pH values. Swelling measurements were determined for each step of the complete development process. (J.S.R.)

**304** HIGH RESOLUTION MASS SPECTROMETER WITH MULTI-STAGE FIELDS. Matsuda, Hisashi (Osaka Univ.). Shitsuryo Bunseki, 14: 78-81(June 1966). (In Japanese).

A mass spectrometer which may have very large mass dispersion and resolving power is proposed. It incorporates the tandem combination of n cylindrical electrostatic analyzers of sector type (opposite deflections to each other) with the same $a_e$, $\Phi_e$, and magnification X(<1) each, and the tandem combination of n homogeneous magnetic analyzers of sector type (opposite deflections to each other) with the same $a_m$, $\Phi_m$, and magnification 1/X each. These two field groups are connected in tandem so that the deflection in the final electric field and that in the first magnetic field are in the same direction. The double focusing condition is satisfied if $a_e = a_m = a$. The total magnification of the image is 1, while the mass dispersion at the final image is given as follows: $D_m = (a/2)[1 + (1/X)][1 + (1/X) + (1/X^2) + \ldots + (1/X^{n-1})]\ \gamma$. If X is very small and n large, then very large mass dispersion and resolving power may be expected. For example, in the case X = 1/3, n = 3, $a_e = a_m$ = 100 cm, $\Phi_e = 63°39'$, $\Phi_m = 90°$, mass dispersion of 2600 $\gamma$ cm and resolving power of 26,000,000/s$\mu$ are expected. (NSA of Japan)

**305** NEW METHOD OF ASSESSING THE PERFORMANCE OF SCINTILLATION CAMERAS AND SCANNERS. Cradduck, T. D.; Fedoruk, Sylvia O.; Reid, W. B. (University Hospital, Saskatoon, Sask.). Phys. Med. Biol., 11: 423-35(1966).

Methods are described to make possible the comparisons of spatial resolution, sensitivity, and distortion for stationary and moving detector scanners. The spatial resolution is measured in terms of the modulation transfer function derived from a simple line source. The sensitivity is expressed as counts per minute for a distributed source and this is combined with the modulation transfer function to give a figure of comparison. The distortion of a stationary detector scanner may be measured as number distortion which gives a differential linearity plot. These methods have been used to compare the performance of a scintillation camera using difference and ratio circuits and, as expected, the ratio circuits exhibit improved performance characteristics. (auth)

**306** POLARIZATION OF DIAMOND COUNTERS. Afanaseva, E. A.; Agababyan, E. V. (Lebedev Inst. of Physics, Moscow). Izv. Akad. Nauk Arm. SSR, Ser. Fiz. Mat. Nauk, 18: No. 6, 80-90(1965). (In Russian).

The polarization of a semiconductor particle is defined as the drop in the amplitude of pulses from particles, with increasing irradiation dose. Since this adversely affects the performance of the semiconductor counter, measurements were made to determine whether the field in the counter was uniform prior to the start of the irradiation and to determine the dependence of the polarization of the counter on the applied d-c voltage. Diamond was chosen because of the availability of a larger amount of published data. Five plane-parallel diamond plates were exposed in vacuum ~$10^{-4}$ mm Hg to alpha particles of $^{238+242}Pu$, at an intensity of approximately $10^3$ particles/sec. The bombarding particles were incident on the diamond through an electrode (~500 Å of gold). The maximum pulse, the integrating counting rate, and the pulse-height distribution were measured. The results show that the customary explanation, wherein polarization is attributed to distortion of the initially uniform field in the crystal (as a result of trapping of the electrons), is incorrect, since the field cannot be uniform in the counter before the passage of the pulse and the usual photoconductivity theory is not applicable. It is concluded that effects of dark photoconductivity and intrinsic polarization of the crystal, which are neglected in the ordinary theory, must be taken into account for a correct explanation of the phenomenon. Differences between the results of bombardment through the anode and through the cathode are due to differences in the capture cross sections of the electrons and the holes. A model based on several experimental facts is proposed to explain the polarization. (ATD)

**307** DETERMINATION OF THE REAL NUMBER OF EVENTS AND THE PROBABILITY OF CALCULATING IT USING THE DATA OF TWO OR THREE INDEPENDENT OBSERVATIONS. Diamandiev, V.; Todorov, T. Compt. Rend. Acad. Bulg. Sci., 19: 97-9(1966). (In Russian).

On working with nuclear emulsions it is necessary to determine the true number of events and the probability of finding an event in a given volume from the data of a number of independent scans of this volume. Let n be the true number of events; $n_1$ and $n_2$ are the number of events counted respectively during the first and second scan; $x_1$ and $x_2$ are the number of events found respectively only during the first and second scan; $x_{12}$ is the number of total events found during the first and second scan. The probabilities of finding a separate event during the first and second scan respectively are $p_1$ and $p_2$, and the probabilities of not finding them are $q_1$ and $q_2$. The term $n_0$ indicates the number of all events detected. Then, $n_1 = x_1 + x_2$; $n_2 = x_2 + x_{12}$; $n_0 = x_1 + x_2 + x_{12} = n_1 + n_2 - x_{12}$; $p_i = 1 - q_1$. The events in the numbers $x_1$, $x_2$, $x_{12}$ and $n - n_0$ are observed respectively with probabilities $p_1q_2$, $p_2q_p$, $p_1p_2$, and $q_1q_2$. A formula is given for finding the probability of all these groups of events. With a double scan the value of $n = n_1n_2/x_{12}$. With a triple scan $n = [A + \sqrt{A^2 - 4n_1n_2n_3B}]/2B$. Here $A = n_1n_2 + n_1n_3 + n_2n_3$ and $B = n_1 + n_2 + n_3 - n_0$. Dispersions are also calculated for n, $p_1$, and $p_2$. (TTT)

**308** CALIBRATION OF SCINTILLATION COUNTERS WITH CONSIDERATION OF SCATTERED $\gamma$ RADIATION. Vasilev, M. B. At. Energ. (USSR), 21: 121-5(Aug. 1966). (In Russian).

A scintillation counter calibration method that takes into account $\gamma$-emission scattering is described. The accumulation factors from radium source radiation reflection and the analytical approximations are found. Formulas are developed for the total direct and scattered $\gamma$-radiation intensity which enable counter calibration without distortion from the scattered radiation. (R.V.J.)

**309** ACCUMULATION FACTORS IN REFLECTING RADIATION FOR COUNTERS WITH DIFFERENT LOWER POWER LEVELS. Vasilev, M. B.; Merkel, M. A. At. Energ. (USSR), 21: 134-5(Aug. 1966). (In Russian).

The accumulation factors for reflected radiation from a point isotopic radium source containing 0.1 mg radium at 1.5 m elevation and the initial discrimination threshold of 66, 108, and 167 keV are tabulated. The curve of the accumulation factor as a function of the distance r and various lower power levels shows that the variations of the lower power levels do not affect the accumulation factor. (R.V.J.)

**310** QUICK MEASUREMENT OF AIRBORNE LONG-LIVED $\alpha$-ISOTOPE CONCENTRATIONS OF ORDER OF $10^{-16}$ TO $10^{-17}$ C/l AND OF THORON DECAY AEROSOLS.

Chutkin, O. A.; Vishnyakov, V. E. At. Energ. (USSR), 21: 138-41(Aug. 1966). (In Russian).

Rapid measurements of long-life α-active aerosols were carried out with the newly developed α-emission (9014-01) ionization spectrometer with 1.7% resolving power and capable of measuring flat specimens up to 160 mm in diameter. The ionization chamber of the spectrometer recorded most of the α emissions with particle energies up to 9 MeV, among them the products of radon, thoron, and actinon decay. The "false" active concentration of long life α-active isotopes was calculated for each aerosol specimen. The α-emission spectra for natural aerosol particles, obtained by means of ionization chamber (50 $m^3$ specimen, 0.13 $mg/cm^3$ precipitate thickness and 120 min exposure), showed that the natural background interference in recording the long life isotopes was 10 to 15 times smaller than in the best radiometers; however, the spectrometer has not been able to record concentration of $10^{-16}$ to $10^{-17}$ C/l without 24 hr exposure. A rapid determination of $^{234}U$ and $^{239}Pu$ mixture with $5.3 \times 10^{-17}$ and $3.7 \times 10^{-16}$ C/l concentration, respectively, was made in the air. The order of error in comparison with the long exposure was about 25%. It was concluded that the ionization spectrometer is sufficiently accurate for recording small concentrations of long-lived isotopes with long exposure or with rapid measurements in which the instrument sensitivity reaches $1 \times 10^{-17}$ C/l. (R.V.J.)

**311** INPUT AND OUTPUT CONCENTRATION RATIO OF RADIOACTIVE GASES FLOWING THROUGH DOSIMETRIC CHAMBER DZ-70. Kornilenko, I. I.; Zybin, V. A.; Bochkov, A. L. At. Energ. (USSR), 21: 137-8(Aug. 1966). (In Russian).

The ratio of input and output concentration of radioactive gas was studied using a 70 l, 40.5 cm diameter, and 55 cm long ionization chamber, DZ-70, which had 0.8 cm input and output gaps in diametrically opposite directions at a distance of 16.7 cm from the chamber axis. Graphs for the integral count of $^{41}Ar$ as a function of time are presented for a pumping rate of P = 60 l/min, taking into consideration the background and the decay. The air-exchange constant in the chamber is also analyzed as a function of P/V and is compared with the data for the DZ-20 chamber. (G.O.Y.)

**312** WINDOWLESS COUNTER WITH SUPPLEMENTARY FIELD IN THE REGION OF THE RADIATION ADMISSION OPENING. Wegner, Lutz Axel. Nukleonik, 8: 266-72(June 1966). (In German).

The mechanism of β particle detection for windowless counters with slit-like radiation inlet apertures was described. With the help of measurements on electrically conducting preparations and a duplicate circuit diagram the ratios that appear in the measurement of poorly conducting preparations were estimated. A method was outlined for obtaining a linear dependence of the counting rate on the surface density of the β particles in this case. (tr-auth)

**313** COSMIC-RAY CHARGE SPECTROMETER. Parnell, T. A. (Univ. of North Carolina, Chapel Hill); Palmatier, E. D.; Mace, R. Contract NASw-59. Rev. Sci. Instrum., 37: 1589-91(Nov. 1966).

A gas filled Čerenkov radiation detector was combined with solid detectors to measure the charge and flux of relativistic primary cosmic rays. Data from a high altitude balloon flight, using a NaI crystal as $\Delta E/\Delta x$ detector, indicate a clear separation of protons from α particles. The resolution may be improved with a solid Čerenkov detector replacing the NaI crystal. (auth)

**314** VERSATILE GATED DISCRIMINATOR WITH ADJUSTABLE PARALYSIS USEFUL IN FAST-SLOW COINCIDENCE EXPERIMENTS. De Volpi, A.; English, J. J.; Metz, A. J.; Porges, K. G.; Rudnick, S. J. (Argonne National Lab., Ill.). Rev. Sci. Instrum., 37: 1592-1600(Nov. 1966).

The discriminator described incorporates a number of features useful in nuclear applications. The paralysis, or deadtime, is adjustable from 100 nsec to 10 msec; at a fixed temperature it is stable to within ±1%, even for pulse pair separations approaching the paralysis time: hence deadtime corrections are correspondingly accurate. Two pairs of 100 MHz logic outputs and a separate scaler driver output are provided. The scaler output can be controlled by external coincidence gating or blocking signals. These gating provisions make it possible to connect a dual module (without additional circuitry) as a single channel analyzer, as an antiwalk discriminator for precise coincidence timing, or even as a coincidence circuit. The primary application is, however, coincidence counting when one or more side channels are needed for amplitude selection. The coincidence gating provision of this discriminator permits one to dispense with lengthy external delay compensation required by conventional energy selecting coincidence schemes. The similarity of the three approaches: conventional slow-fast, conventional fast-slow, and gated fast-slow, in terms of coincidence computations and accidental monitoring is demonstrated, and criteria are presented to aid in selection of one technique over the others. (auth)

**315** DISTRIBUTION OF IMPURITIES AND THE VARIATION OF ELECTRIC FIELD IN THE DRIFT REGION OF SILICON p-i-n DETECTORS. Antonov, A. S. (Joint Inst. for Nuclear Research, Moscow). Soviet Phys.-Solid State (Engl. Transl.), 8: 1061-3(Nov. 1966). Translated from Fiz. Tverd. Tela, 8: 1325-8(May 1966).

The concentration of impurities in the drift region of silicon p−i−n detectors was determined by measuring their capacitance as a function of reverse bias. The electric field distribution in this region was found. An analysis of the experimental results yielded a general expression for the electric field magnitude. (auth)

**316** TOTAL-ABSORPTION GAMMA RAY SPECTROMETER SYSTEM FOR PULSED BEAM (n,n'γ) MEASUREMENTS. Ashe, John B.; Morgan, Ira Lon; Hall, J. D. (Texas Nuclear Corp., Austin). Rev. Sci. Instrum., 37: 1559-61(Nov. 1966).

A gamma ray spectrometer that combines the techniques of neutron time-of-flight spectroscopy and gamma ray total absorption spectroscopy is described. Data on gamma ray pulse-height resolution and photopeak efficiency are presented. Representative pulse-height spectra from neutron inelastic scattering reactions are shown. (auth)

**317** PROPORTIONAL COUNTER FOR DETECTION OF IONS AND ATOMS IN KILOELECTRONVOLT ENERGY RANGE. McClure, G. W.; Allensworth, D. L. (Sandia Lab., Albuquerque, N. Mex.). Contract AT(29-1)-789. Rev. Sci. Instrum., 37: 1511-15(Nov. 1966). (SC-DC-66-1549).

A proportional counter designed as a detector of ions and neutral atoms for use in collision experiments at kiloelectron volt energies is described. Response to 1−40 keV $H^+$ ions and 5−40 keV $Ar^+$ and $N^+$ ions is investigated. Particles enter the detector from an attached evacuated chamber through a thin film covered narrow slit or through a differentially pumped open aperture. Construction of the counter and performance with both types of aperture are described. Performance is evaluated in terms of two statistical measures of the differential pulse height distribution−the most probable pulse height and the pulse height spread. Sufficient data are given to permit evaluation of the proportional counter as an ion energy spectrometer. Measurements of scattering and energy loss of protons in the thin film window are described. (auth)

**318** WIDE GAP CHAMBER OF CYLINDRICAL GEOMETRY OPERATED CLOSE TO GROUNDED OBJECTS. Leontic, B. A. (Brookhaven National Lab., Upton, N. Y.). Contract AT(30-2)-Gen-16. Rev. Sci. Instrum., 37: 1468-71(Nov. 1966). (BNL-10154).

A cylindrical spark chamber consisting of only two electrodes, the radii of which differed by a factor of more than 3, was successfully operated while surrounded by grounded conductors, one of which was situated at a distance of only 4.5 mm from the sensitive volume of the chamber. Very thin and straight tracks were obtained which followed the particle trajectory up to large inclinations from the normals to the surface of the electrodes. (auth)

**319** REPRESENTATIONS OF THREE-DIMENSIONAL ENERGY SPECTRA. Bregman, F. Philips Tech. Rev., 27: 132-3(1966).

A brief description is given of a few pictures produced with a 4096-channel pulse-height analyser (kick sorter) as used for recording energy spectra of radioactive radiation. The illustrations show various ways in which a spectrum with two independent variables can be displayed with the aid of an x-y recorder or on an oscilloscope. (auth)

**320** ADVANCED ALPHA-BETA-GAMMA HAND AND SHOE MONITOR (Engineering Drawings). (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). (CAPE-1489).

18 drawings.

The design incorporates features applicable for alpha-beta-gamma, beta-gamma, and alpha only monitoring in a reliable and efficient manner. Special light pipes, probe-contained preamplifiers, and solid-state circuitry with no relays are used to provide a satisfactory signal-to-noise ratio. Solid state circuits were developed and fabricated on printed circuit cards compatible with commercially available card files. The circuits, combined with commercially available logic units, reduce capital and maintenance costs. Scintillation probes are employed. (For details see TID-4100 Suppl. 37) (F.S.)

**321** 72-IN. HYDROGEN BUBBLE CHAMBER MAGNET CARRIAGE (Engineering Drawings). (California Univ., Berkeley. Lawrence Radiation Lab.). (CAPE-1454).

223 drawings.

The magnet carriage is used to support, lift, and transport the combined weight of the 72 in. hydrogen bubble chamber and related equipment. Direction of travel is determined by rotating pads attached to the four corners of the magnet. Clockwise and counterclockwise rotation about the vertical axis of the magnet and straight line progress in any direction may be made. (For details see TID-4100 Suppl. 37) (F.S.)

**322** EVOLUTION OF A RADIATION MONITORING SYSTEM FOR MANNED SPACE TRAVEL. Corkhill, D. J. 3p. (CONF-660432-2). ORAU. Gmelin, AED-CONF-66-077-2.

From Aerospace Medical Association, 37th Annual Scientific Meeting, Las Vegas, Nev.

Two space radiation monitoring systems developed for manned space travel are discussed. Topics include categorization of particle intensities, system specifications, and development status. (B.G.D.)

**323** EXPERIMENTAL TECHNIQUES AND STANDARDS USED FOR EVALUATING AND CALIBRATING SURVEY INSTRUMENTS. Thompson, I. M. G. (Central Electricity Generating Board, Berkeley, Eng.). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/5, 18p. (CONF-660807-33). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

During the past three years neutron survey instruments have been calibrated against measured neutron fluxes in the energy range from thermal to 20 MeV. Thermal neutron monitors are calibrated in fluxes produced by moderating D/D neutrons in a polythene assembly, the flux density being measured by calibrated $BF_3$ counters. To measure neutron fluxes in the range from 30 keV to 20 MeV a long counter is used, which has been calibrated with sealed neutron sources of known outputs. The manganese sulphate bath technique has been employed to determine the outputs from the neutron sources, and a comparison with the N.P.L. manganese bath for the output from a 3-curie americium/beryllium source gave agreement to within 0.4%. A simplified technique using activated manganese foil is employed to calibrate the detectors used in the manganese bath experiment. The A.W.R.E. 3-MeV Van de Graaff was used to produce neutrons with energies from 30 keV to 2.1 MeV and from 16 MeV to 19 MeV. The $^7Li(p,n)^7Be$ reaction was used to give neutrons from 30 keV to 500 keV, the $T(p,n)^3He$ reaction was used for the range of 700 keV to 2.1 MeV, and the $T(d,n)^4He$ reaction was used for the range 16 to 19 MeV. The positive ion accelerator at Berkeley is used to produce 2.5 MeV neutrons from the $D(d,n)^3He$ reaction, and 14 MeV neutrons from the $T(d,n)^4He$ reaction. A standard thermal flux density was established using four americium/beryllium $(\alpha,n)$ neutron sources in a graphite moderator, this flux will be used to calibrate foils and other detectors useful in the establishment of standards. The characteristics of some health physics survey instruments, as determined by the calibration techniques described, are briefly discussed. (auth)

**324** FLUX MEASUREMENTS OF MEDIUM ENERGY NEUTRONS USING STILBENE SCINTILLATORS AND $^6Li$ GLASSES. Bormann, M.; Neuert, H.; Balzer, H.; Geisler, J.; Magdanz, G. (Univ., Hamburg). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/22, 14p. (CONF-660807-12). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

Earlier investigations on flux measurements for 14-MeV neutrons using inorganic (stilbene) scintillators (1″ × 1″) delivering an accuracy of about 4% were extended to 2.5-MeV neutrons from $D(D,n)^3He$. Effects of gamma radiation were excluded by applying pulse shape discrimination. Edge effects and multiple np scattering can be accounted for. The results were checked by comparative measurements using a $^6LiI(Eu)$ scintillator, and by counting the beta radiation of $^{32}P$ from $^{32}S(np)$ in $2\pi$ geometry with a methane flow proportional counter. The stilbene scintillator counter can therefore be regarded as an accurate instrument for measuring the absolute flux of medium-range energy neutrons paired with a good energy resolution. In many cases low-cost instruments for monitoring the neutron flux in fixed local points in neutron laboratories are wanted which have a good long-time stability. As we feel that $^6Li$ glass scintillators are very appropriate tools for that purpose some further investigations were performed with NE 902, NE 905, NE 907 and NE 908 glasses. The results with monoenergetic neutrons were that flux measurements including some energy resolution can be made up to energies of about 2 MeV, with lower accuracy at the higher energies. The best results were found with NE 905. As experiments with definite $\gamma$ rays showed that pulses from slow neutrons can well be discriminated from $\gamma$ pulses, further experiments were started with counters where the $^6Li$ glasses on top of a lucite light guide and a 150 AVP multiplier were surrounded with hydrogen containing materials of appropriate thickness ($(CH_2)_n \approx 12$ cm). All neutrons are now counted within a small thermal neutron peak in the pulse spectrum. The efficiency of these counters is about $10^{-2}$ depending on glass size, somewhat decreasing with neutron energies (up to 20 MeV). An accuracy of better than 10% of flux destination is claimed after checking the counters with stilbene counters and $^6LiI$ counters. $^6Li$ glass counters proved to keep their properties much more stable for long periods than stilbene crystal or $^6LiI$-crystal counters do. The counting efficiency is sufficiently high, the discrimination with respect to $\gamma$ pulses is much less critical than with $BF_3$(long)-counters. So these counters can be established for neutron flux monitoring with good reliability. (auth)

**325** FAST-NEUTRON DETECTION AND SPECTROMETRY WITH GASEOUS SCINTILLATORS. Blanc, D.; Galy, J.; Teyssier, J.-L. (Faculte des Sciences, Toulouse). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/25, 18p. (In French). (CONF-660807-9). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

In view of their fast response and low sensitivity to gamma radiation, gaseous scintillators are attractive neutron spectrometers. However, for fast-neutron detection, filling pressures must be of the order of several tens of atmospheres. Helium is used as both target and scintillator. Its impurity content is 5 ppM nitrogen, 5 ppM oxygen and 3 ppM vapour. The properties of this detector when exposed to alpha particles from $^{210}Po$ was studied, finding that the amount of light collected decreases when the pressure

is raised from 6 to 40 atm. The addition of nitrogen in concentrations of less than 10% shows that this decrease does not depend on the amount of nitrogen introduced, which explains why the phenomenon is observed when impurities are present in trace amounts. To increase the light output in the case of high-pressure filling, a wavelength converter was used which was deposited on an aluminium layer which served as a reflector. This substance in question was sodium salicylate, whose conversion efficiency is constant between 850 and 2500°A. Moreover, it releases little gas and detector response does not vary with time. The decrease in light intensity as a function of pressure is definitely less pronounced than when the converter is omitted. The salicylate deposit on the scintillation chamber port improves photon collection. The effects of geometry inside the detector are studied for this case. The 14 MeV neutrons produced by the (d,t) reaction are detected by means of the helium recoil nuclei produced by elastic scattering. Background noise is eliminated by the use of a coincidence circuit with a resolution time of 10 nanoseconds. The shape of the energy spectra of the recoil nuclei is explained by establishing what changes have to be made in the theoretical spectra in order to reproduce the same shape. Allowance has to be made for edge effects and energy resolution since the experiment involves a luminous source with emission centres distributed throughout the gas. (auth)

**326** A DOUBLE SUMMATION CIRCUIT IN A NEUTRON SCINTILLATION SPECTROMETER WITH GAMMA BACKGROUND DISCRIMINATION USING DE-EXCITATION TIME. Kukhtevich, V. I.; Trykov, L. A.; Trykov, O. A. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/53, 14p. (In Russian). (CONF-660807-22). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

A gamma-ray discrimination circuit using scintillation decay time is described. This circuit can be used for the spectrometry of neutrons with an energy threshold $E_n$ = 0.2 MeV and gives gamma-ray discrimination of $\sim 5 \times 10^{-4}$ in the energy range 0.2–0.3 MeV. The above energy threshold and the gamma-ray suppression factor are achieved by double summation in a compensation circuit, which suppresses positive emission caused by high-energy gamma rays. Energy distributions for Ra–Be and Po–Be sources are given to illustrate the working of the spectrometer. (auth)

**327** MEASUREMENT OF FAST-NEUTRON SPECTRA USING A SINGLE-CRYSTAL SCINTILLATION SPECTROMETER WITH A STILBENE CRYSTAL. Goryachev, I. V.; Kukhtevich, V. I.; Trykov, L. A.; Trykov, O. A. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/54, 24p. (In Russian). (CONF-660807-17). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The circuit of a single-crystal scintillation spectrometer is described with discrimination against gamma radiation by scintillation decay time. The spectrometer described can be used for measuring energy distributions of neutrons with a threshold above 0.1 to 0.2 MeV with the total counting rate of the spectrometer not exceeding $6 \times 10^3$ counts/sec and a gamma ray suppression factor for the above neutron threshold of the order of $10^{-3}$. The effect of the following on the measured energy distributions is discussed: the dimensions of the stilbene crystal, the lead filter which is included for additional gamma-ray suppression, the orientation of the crystal axis relative to the incident neutron beam, and the detector collimation. The following energy distributions are given to illustrate the operation of the spectrometer: spectra from standard neutron sources (energy threshold $E_n$ = 0.2–0.3 MeV), Po–Be, Pu–Be, Po–B and Ra–Be (the energy distributions obtained for these sources are compared with the experimental and calculated data of other authors); neutron spectra for the reaction $^9Be(d,n)^{10}B$ with $E_d$ = 0.55 and 0.84 MeV; spectra of reactor neutrons passing through iron shields of varying thickness (14–40 cm); and spectra of reactor neutrons passing through beryllium shields (6 and 14 cm). The possibility of using the spectrometer for measuring energy distributions and gamma-ray dose rate with a neutron background is considered. Gamma-ray spectra obtained with this spectrometer from the radioactive sources $^{134}Cs$ and $^{60}Co$ and from other sources are presented. (auth)

**328** SOME QUESTIONS OF METHOD IN CONNECTION WITH THE SPECTROMETRIC STUDY OF MIXED GAMMA-NEUTRON RADIATION FIELDS. Fedorov, V. A.; Doroshenko, G. G. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/50, 8p. (In Russian). (CONF-660807-16). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

For investigating the characteristics of mixed gamma-neutron fields use is generally made of detectors that are sensitive to one of the types of radiation under study, and in determining the partial dose either the energy dependence of the detector's sensitivity is adjusted to that of the radiation quality factor, or the energy spectrum is measured and the dose is then calculated. A method of calculation is proposed for identifying the types of radiation; by this method, full use can be made of information obtained with detectors that are sensitive to both types of radiation, and partial energy spectra and also total or partial doses can be obtained directly with different spectrometric detectors. The method consists essentially in working out appropriate equations that link detector response with the characteristics of the field being studied and in using special weighting functions for spectrometric determination of the total and partial characteristics of the mixed field. (auth)

**329** DOSIMETRY IN A MIXED (GAMMA-RAY AND FAST-NEUTRON) FIELD, USING IONIZATION CHAMBERS FILLED WITH A LIQUID DIELECTRIC. Blanc, D. (Faculte des Sciences, Toulouse); Mathieu, J.; Patau, J.-P.; Francois, H.; Soudain, G. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/26, 10p. (In French). (CONF-660807-10). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

Using an ionization chamber filled with pure hexane or a mixture of hexane and carbon tetrachloride, which is tissue-equivalent for gamma rays, one can not only determine the total absorbed dose in a complex flux of gamma rays and fast neutrons, but also quickly establish the partial doses due to one or the other of these two radiations. Detectors comprising plane parallel electrodes or co-axial cylindrical electrodes were used and experiments were carried out on mixed fields of 14.7 MeV neutrons and gamma rays produced by $^{60}Co$ or $^{137}Cs$ sources. Provided that the fluence remains constant for a few minutes, the absorbed dose for each of the two components of the radiation can be deduced by a simple graphic procedure from measurements of the ionization current for two different and well-known values of the voltage between the electrodes of the chamber. (auth)

## Radiation Dosimeters

*Refer also to abstract 96.*

**330** (AD-631318) MANUAL OF RADIATION DOSIMETRY EXPERIMENTS. Humphreys, Kent C. (Edgerton, Germeshausen and Grier, Inc., Santa Barbara, Calif.). Nov. 1965. Contract DA-49-146-XZ-226. 218p. (AFRRI-CR-65-4). CFSTI $6.00 cy, $1.25 mn.

An instruction manual is presented which includes topics on experimental cavity ionization, tissue equivalent ionization chambers, thermal neutron measurements, threshold foils for neutron detection, measurement of fast neutron tissue dose with the Hurst proportional counter, a scintillation dosimeter, silver-activated phosphate glass microdosimeters for gamma dose measurement, chemical dosimetry systems, measurement of depth dose, and film dosimetry. (auth)

**331** INTEGRATING DOSIMETRY OF IONIZING RADIATION WITH LUMINESCING SYSTEMS. Frank,

Manfred; Herforth, Lieselott; Stolz, Werner (Technische Univ., Dresden). Wiss. Z. Tech. Univ. Dresden, 14: 1119-25(1965). (In German).

A description of luminescence dosimeters capable of integration is given without an evaluation with respect to other dosimeter types. There is no all-purpose luminescence dosimeter. Among inorganic dosimeters are found thermo-luminescence dosimeters, with increasing lower limits of sensitivity in the order $CaSO_4$: Mn (50 μrad), $CaF_2$: Mn (1 mrad), LiF-TLD system (10 mrad), $AlPO_4$ glass (10 mrad), LiF system Lumimeter-Lumivad (1 rad). Dosimetry with ir stimulated phosphors and exo-electron emission is discussed. Radiophotoluminescence detectors with high Z glass, low Z glass, and Yokota glass are reviewed. Among organic luminescence dosimeters, fluorescence decay may be measured with quinine sulfate or with liquid scintillator solutions. Fluorescence buildup is studied with the Ca benzoate dosimeter or with the terephthalic acid dosimeter. Fluorescence decay may be studied in crystals or plastics as well. The applications of various systems to certain application ranges are outlined. (BBB)

**332** AUTOMATIC ELECTRON GAMMA-RATE METER. Gostishchev, V. S.; Skibenko, V. G. Defektoskopiya, No. 3, 16-19(1966). (In Russian).

The construction and performance of a γ rate meter used for determining film exposure during defectoscopy are given. (R.V.J.)

**333** USE OF THERMOLUMINESCENT ALUMOPHOSPHATE GLASS IN PERSONNEL NEUTRON DOSIMETERS. Bochvar, I. A.; Keirim-Markus, I. B.; Prosina, T. I.; Yakubik, V. V. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/48, 22p. (In Russian). (CONF-660807-11). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The possibility of using thermoluminescent alumophosphate glass in personnel neutron dosimeters is discussed. After analyzing the available methods of recording neutrons over a wide energy range, the measurement of slow neutrons using detectors with a cross-section obeying the 1/v law was the method adopted. It is shown that lithium and boron are promising materials for doping the glass, and the characteristics of a number of glass samples containing these elements are investigated. In addition, the technological properties of glass containing different amounts of lithium were determined and the dependence of luminescence on the composition of the glass and the concentration of the activator, the dependence on radiation dose, and fading as a function of storage time were investigated. The sensitivity of these various compositions to slow neutrons and gamma radiation, and also the stability of their characteristics were studied. Phantom measurements are carried out in monoenergetic neutron fluxes with glass dosimeters containing lithium. As a result of the investigations a suitable composition for glass required to possess fairly high sensitivity to slow neutrons for personnel dosimetry in mixed fields of gammas and neutrons of different spectra was suggested. (auth)

**334** USE OF FISSIONABLE SUBSTANCES IN NEUTRON DOSIMETRY. Keirim-Markus, I. B.; Kraitor, S. N. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/51, 16p. (In Russian). (CONF-660807-21). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

A neutron dosimetry method is presented that makes use of several fissionable substances and permits direct measurement of the values of interest in dosimetry by the number of fission events. It is shown that by selecting boron filters and fissionable materials with different fission thresholds one can obtain a neutron recording efficiency that reproduces dose curves (neutron energy dependence of the maximum surface dose equivalent and of the first-collision dose). The characteristics and construction of a detector for use in neutron dosimetry are described, and the possibilities of using different detector types (scintillation, ionization, etc.) for recording fission fragments are discussed. The possibility of direct neutron dose measurement by the number of fission events in a personnel dosimeter is considered. For recording fission fragments they propose using special glass, and also Lavsan (polyester fibre) tissues or nuclear emulsions in the personnel dosimeter. (auth)

**335** RADIATION ELEMENTS FOR DOSIMETRY OF NEUTRONS AND MIXED RADIATION. Hosemann, R.; Warrikhoff, H.; Haase, J.; Melde, D.; Junker, D. (Max-Planck-Gesellschaft, Berlin). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/20, 11p. (CONF-660807-18). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The neutron sensitivity of a neutron element is proportional to the specific electron efficiency of the outer electrode. This efficiency increases with increasing cross section for activation of the electrode. The cross section has its highest values for thermal neutrons. Neutron elements for thermal neutrons with outer activated electrodes of 1.5 cm in diameter, made of rhodium respectively silver, yield a sensitivity of 45 V/rad respectively 20 V/rad. The maximum gamma sensitivity of the neutron element with rhodium electrode is less than 2% of the sensitivity of thermal neutrons. Radiation elements with the same sensitivity to x and gamma rays and thermal neutrons of approximately 0.5 V/rad, can easily be constructed, when some part of the one electrode of a gamma element is exchanged by rhodium or silver. An improved construction reduces the over-all length of a dosimeter with radiation element to 6 cm. (auth)

**336** CADMIUM CONTAINING NEUTRON SCREEN. Hansen, Niels; Thomas, Jorgen (to Atomenergikommissionen). British Patent 1,044,924. Oct. 5, 1966. Priority date Aug. 21, 1963, Denmark.

A neutron screening material is described which consists of a sintered ceramic cadmium compound (cadmium oxide) and aluminum for improving workability. (M.H.R.)

## Radiometric Instruments

*Refer also to abstracts 185 and 244.*

**337** INDUSTRIAL RADIOGRAPHY-FACILITY PLANNING AND IMPLEMENTATION. Stenske, Donald B. (Univ. of Wisconsin, Madison). 15p. (CONF-660333-1). ORAU. Gmelin, AED-CONF-66-242-1.

From Society for Nondestructive Testing, Milwaukee.

Procedural patterns leading to an industrial radiography installation of interest to engineers, supervisory personnel, and quality control people are summarized. Radiographic sources described include x-ray tubes and various radioisotopes which emit alpha and beta particles, and gamma rays. Several aspects of radiography are discussed. (F.S.)

## Miscellaneous Instruments and Components

*Refer also to abstracts 692, 706, 843, and 1156.*

**338** (AD-631496) PARTICLE VELOCIMETER FOR USE CLOSE-IN TO UNDERGROUND EXPLOSIONS. Formal Report, Phase 4. Danek, William L. Jr.; Dargis, Algimantas A. (Engineering Physics Co., Rockville, Md.). Dec. 31, 1965. Contract DA-49-146-XZ-224. 93p. (DASA-1431-2). CFSTI $3.00 cy, $0.75 mn.

Phase IV has consisted of designing a power supply to provide the high currents required and incorporating the power supply into the gage body, examining methods of increasing the signal gain of the velocimeter in order that the practical measurement range of the gage in field use may be extended down to velocities of tens of meters per

second, determining the most suitable data recording method for use with the gage in the field, and improving the shock velocity generator utilized in laboratory tests. This report describes these Phase IV activities in their detail. (auth)

**339** (AD–636265) A THERMAL PULSE SHAPER MECHANISM. Zagieboylo, Walter; Levine, Arthur (Quartermaster Research and Engineering Command, Natick, Mass.). Nov. 16, 1960. 26p. (T–31). CFSTI $2.60 cy, $0.50 mn.

A shaped pulse of intense thermal radiation, corresponding to the pulses from nuclear weapons, is obtained by the output of a QM carbon arc. A fly-wheel driven by a d-c motor actuated a venetian blind shutter placed between a mirror and the target to control the flux. The combination produced reasonably good simulation and reproduction of the generalized field pulse. (auth)

**340** (AERE-R–5270) A PROGRAMMED ASSOCIATIVE MULTICHANNEL ANALYSER. Best, G. C. (Atomic Energy Research Establishment, Harwell (England)). Aug. 1966. 20p. Dep. mn. BIS $1.00. HMSO 5s.

The use of a small computer as an associative analyzer is discussed with special reference to the PDP8. The advantages and limitations of the method are discussed and general program algorithms presented. (auth)

**341** (EUR–3062.i) CONTATORI DECIMALI REVERSIBILI. (Reversible Decimal Counters). Battistelli, G. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Aug. 1966. 14p. Dep. mn.

A general analysis of a decimal scaler obtained from four binaries controlled by logic gates is described. The method to find the boolean equations that determine their behavior is shown. Some types of reversible counters developed in the electronic laboratory are compared with regard to cost and number of components. (auth)

**342** (NYO–3622-5) APPLICATIONS OF ULTRASONIC ENERGY: ULTRASONIC INSTRUMENTATION FOR NUCLEAR APPLICATIONS. Bimonthly Progress Report No. 30, August 1, 1966–September 30, 1966. (Aeroprojects, Inc., West Chester, Pa.). Oct. 1966. Contract AT(30-1)-3622. 18p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The incipient boiling detector is being reassembled at a new test facility, following the installation of an exponential terminal coupler designed to decrease the power sensitivity of the system. Operability of the ultrasonic flowmeter was confirmed in tests conducted during the reporting period. Additional refinements suggested by these results are being investigated. Recently initiated studies of ultrasonic techniques for measuring pressure in high-temperature systems have indicated possible infeasibility of approaches based on direct acoustic response to pressure variations. Investigations are proceeding on a cavitation threshold power approach. (auth)

**343** (ORO–2972-6) TIME-SHARED ON-LINE COMPUTER-BASED NUCLEAR DATA ACQUISITION SYSTEM. Page, J. G.; Collins, R. J. (Texas Univ., Austin). July 1966. Contract AT(40-1)-2972. 17p. (CONF-660913–2). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Conference on Nuclear Physics, Berkeley, Calif.

A nuclear data acquisition system in operation at the University of Texas accelerator laboratory is described with special reference to the interfacing and programs necessary for time sharing operation. The computer has a short instruction list and is relatively fast. It is equipped with an automatic program priority interrupt system and a data interrupt facility which includes modifications intended to simplify data acquisition and reduction. Connected on-line are two 400-channel pulse-height analysers and three (slow) 1024-channel analog-to-digital converters for use in single- and multiparameter experiments. Remote control panels and several multiplexers which handle the data, program requests, and allow for simultaneous operation of all on-line equipment are included. A time-sharing program handles all on-line program requests for raw data outputs and allows the operation of programs written either in Fortran or source language, or the preparation of new programs simultaneously with data output. (S.F.L.)

**344** (SC-TM–28-63(14)) THE SINISTRON: A HIGH-POWER, LOW-PRESSURE, NANOSECOND SWITCH. Creveling, R. (Sandia Corp., Albuquerque, N. Mex.). July 1963. Contract AT(29-1)-789. 20p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The development of a low-pressure spark gap capable of switching kiloamperes of current at voltages up to 30 kv is discussed. Extremely fast rise times, of the order of $10^{12}$ amperes per second, are feasible. The device is called a Sinistron because it operates on the left or sinistro side of the Paschen curve. By using close electrode spacing, sufficient gas may be present to promote the fast-conduction capability attained in the Sinistron. This mode of operation results in advantages over the conventional or high-pressure spark gap as follows: operation over a wide voltage range; fast, low-jitter starting; low-voltage, low-energy triggering; short, diffused, low-inductance arc; and heavy, fast-rising-current conduction. (auth)

**345** (TID–23392) INEXPENSIVE MULTI-CHANNEL TIME ANALYSER. Fullwood, Ralph R. (Rensselaer Polytechnic Inst., Troy, N. Y. Dept. of Nuclear Engineering and Science). [nd]. Contract AT(30-1)-328. 8p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

An inexpensive 128 channel pulse height analyzer was equipped with a time digitizer which operates in increments ranging from 0.5 μsec to 256 μsec per channel. This in no way interferes with the original ability of the analyzer to switch selectably in Mössbauer, multiscaling, or pulse height modes. The system also features oscilloscope display, printed and punched paper tape output at a total equipment cost of $5500. (auth)

**346** (WASH–1067) HIGH TEMPERATURE THERMOMETRY. Papers Presented at a Seminar at AEC Headquarters, Washington, D. C., February 24–26, 1965. (Division of Reactor Development and Technology (AEC), Washington, D. C.). Mar. 1966. 432p. (CONF-650204). Dep. mn. CFSTI $4.50 cy, $2.00 mn.

Thirty-five papers are included which are arranged according to company or organization. Topics covered include fabrication technology, materials compatibility, service experience, research studies, and advanced techniques. For abstracts of nine individual papers previously abstracted see NSA 19: 15823, 18344, 20277, 20278, 20401, 22664, 22927, and 30489; also NSA 20: 20185. (D.L.C.)

**347** TUNNEL DIODE CHRONOTRON CIRCUIT FOR PICOSECOND RANGE. Venable, William H. Jr. (George Washington Univ., Washington, D. C.). Rev. Sci. Instrum., 37: 1443-9(Nov. 1966).

A multichannel circuit was devised for measuring short time intervals directly with a sequence of timing circuits. The output is in the form of counts per time interval with one and only one output count per pair. Time intervals can be measured from less than 5 psec up to any length of time for which it is practical to build a delay line. With coaxial lines used as delay lines, the timing standard deviation in the Nth channel is $(1.4 + 0.36N)^{\frac{1}{2}}$ psec. The temperature drift of a single channel without temperature compensation is 5 psec/°C and is not cumulative in a long chain of circuits. (auth)

**348** UNIVERSAL CAPACITANCE PROBE LIQUID LEVEL MEASURING SYSTEM. Dinkel, John A. (Argonne National Lab., Ill.). Rev. Sci. Instrum., 37: 1549-54(Nov. 1966).

A universal liquid level measuring system designed for most cryogenic installations is described. A number of remote measuring heads are used with a central indicator to enable one operator to scan or to continuously monitor

liquid levels in a number of vessels. A coaxial probe immersed in the liquid measures the difference in dielectric constants between the liquid and gas phases of the media. The probe and its associated cable constitute the capacity in the tuned circuit of an oscillator, thus a change in liquid level is reflected as an oscillator frequency change. In the indicator unit, the error voltage required to phaselock a local oscillator to a probe oscillator is a function of the probe oscillator frequency. Results are given for a number of test level measurements made with $N_2$ and $^4He$. (auth)

**349** AVERAGE CHARGE DETECTOR FOR MASS SPECTROMETERS. Dimeff, John; Lieber, Albert J.; Burrous, Clifford N. (Ames Research Center, Moffett Field, Calif.). Rev. Sci. Instrum., 37: 1562-6(Nov. 1966).

The results of space experiments designed to determine the intensity and energy distribution of the solar plasma have been somewhat ambiguous because of the inability to provide separate measurements for the $H^+$ and $He^{++}$ components of the plasma stream. An instrument was designed which can provide the required separation with adequate accuracy. Performance data for the instrument presented as a function of ion beam intensity and energy indicate a repeatability of the order of 3%. Data on measurement sensitivity to experimental variables suggest that the repeatability might be significantly better than is indicated by current results. (auth)

**350** HIGH-TEMPERATURE NEUTRON-DIFFRACTION FURNACE. Bowman, M. G.; Hull, D. E.; Witteman, W. G.; Arnold, G. P.; Bowman, A. L. (Los Alamos Scientific Lab., N. Mex.). Rev. Sci. Instrum., 37: 1543-4(Nov. 1966).

An induction transformer furnace for a neutron diffractometer is described. This furnace was used for the examination of refractory carbides by neutron diffraction at temperatures up to 2500°C. (auth)

**351** RECORDING SYSTEM WITH A NUMERICAL COMPUTING DEVICE FOR MULTICHANNEL ANALYSIS. Zhuravlev, B. E.; Zabiyakin, G. I. (Joint Inst. for Nuclear Research, Dubna, USSR). Prib. Tekh. Eksp., No. 2, 81-5 (Mar.-Apr. 1966). (In Russian).

The performance of a multichannel, multiple analysis recording system, operating with a magnetic memory device in a computer, is discussed. The memory device which is a part of a computer retains all the functional bonds with the machine but operates with several independent programming channels. (tr-auth)

**352** PHOTOELECTRONIC MULTIPLIERS WITH LARGE DIAMETER CATHODES AND TOROIDAL MULTIPLYING SYSTEMS. Berkovskii, A. G.; Guselnikov, V. G.; Pankratov, V. M. (Moscow Electric Tube Factory). Prib. Tekh. Eksp., No. 2, 123-8(Mar.-Apr. 1966). (In Russian).

The characteristics of the FEU-63 and FEU-65 photoelectron multipliers are discussed in detail. Both of these multipliers have a cathode diameter of ≥100 mm, a high resolving power, an amplification of $\sim 10^8$, and a linear current yield of the order of one amp. (G.O.Y.)

**353** GENERATOR OF 100 kW PULSES OF 40 msec DURATION. Butakov, L. D.; Solntsev, B. A. (Tomsk Pedagogical Inst., USSR). Prib. Tekh. Eksp., No. 2, 212-14(Mar.–Apr. 1966). (In Russian).

The design of a pulse generator which can generate a rectangular pulse of 40-msec duration is described. The pulse power is 100 kW. The pulses are produced by a delayed volume discharge across a thyratron. The amplitude and frequency of the pulse are 0.3 and 3 μsec, respectively. The diagram given includes a high-frequency thyratron quenching circuit. (G.O.Y.)

**354** DESCRIPTION AND PERFORMANCE OF AN ELECTROMAGNETIC MASS SEPARATOR. Demyanov, A. V.; Tarantin, N. I.; Dyachikhin, Yu. A.; Kabachenko, A. P. (Joint Inst. for Nuclear Research, Dubna, USSR). Prib. Tekh. Eksp., No. 2, 28-33(Mar.-Apr. 1966). (In Russian).

Descriptions are given of a mass separator constructed with an SP-57 type electromagnet. The mass separator is capable of analyzing nuclear reaction products with mass number up to M ~ 260. Data are given on the mass-separator's ion-optical characteristics and the results of experiments for separation of $^{205}Tl$ and $^{203}Tl$ isotopes are included. (tr-auth)

**355** EPR MEASUREMENTS USING RE-1301 RADIO SPECTROMETER AT 4.2 DEG K. Petinov, V. I.; Andreev, O. M. (Inst. of Chemical Physics, Academy of Sciences, USSR). Prib. Tekh. Eksp., No. 2, 96-7(Mar.-Apr. 1966). (In Russian).

The design is given of a cryostat operating with a standard radiospectrometer RE-1301 and capable of measuring EPR at a temperature range from 1.7 to 4.2°K during 8 hr at magnetic field modulation amplitude from 2 to 3 Oersteds at 975 kHz frequency. (tr-auth)

**356** SIMPLE CRYOSTAT FOR COOLING SEMICONDUCTOR NUCLEAR RADIATION DETECTORS. Przyborski, Wincenty (Inst. of Nuclear Research, Swierk, Poland). Nukleonika, 11: 137-8(1966).

A cryostat was designed and constructed for cooling and heating semiconductor radiation detectors at much faster rates than previously described. The novelty of this cryostat consists of the utilization of special, very convenient in this case, thermal, mechanical, and electric properties of teflon. These properties, elasticity in particular, are preserved down to the temperature of about 200°K. (B.G.D.)

**357** PRECISION TECHNIQUE APPARATUS (Engineering Materials). (California Univ., Berkeley. Lawrence Radiation Lab.). (CAPE–1441).

2 drawings.

The apparatus accurately measures azimuthal distortion in camera lenses. A precision cylindrical camera was made with the least number of adjustments possible to avoid setting errors. The setup includes a collimating telescope, cylindrical camera containing the lens to be tested, and the test pattern, which is a grid of 105 illuminated cross hairs (5 rows of 21 columns) set in a flat Al plate 84 in. × 30 in. × 1.5 in. By rotation of the camera, the same portion of the test pattern can be used to check azimuthal distortion in different sectors of the lens. Distortions are recorded on film plates, which are then measured with a linear micrometer. The accuracy obtainable is 1 part in 100,000. (For details, see TID-4100 Suppl. 36) (F.S.)

**358** SOLID STATE LOG N-PERIOD SYSTEM (Engineering Materials). (Savannah River Operations Office (AEC), Aiken, S. C.). (CAPE–1486).

8 drawings.

This log n-period system monitors neutron flux levels and activates safety devices in a nuclear reactor. The system is highly reliable and has all solid-state components. Variable damping improves the accuracy at low levels and provides rapid trips at high power or with fast periods, because response time is determined by both rate of change of current and the current level. (For details see TID-4100, Suppl. 37) (F.S.)

**359** ACCELERATOR DIRECTIONAL COUPLER AND PUMPOUT SECTION (Engineering Materials). (Stanford Linear Accelerator Center, Stanford Univ., Calif.). (CAPE–1484).

14 drawings.

The directional coupler indicates the power and the direction of a voltage inside the waveguides of an accelerator system. The pumpout is used to evacuate the waveguide without disturbing the fields set up in the waveguide. The equipment has been used in the Stanford Linear Accelerator. (For details see TID-4100, Suppl. 37) (F.S.)

**360** SCATTERING CHAMBER WITH MOVABLE ARMS (Engineering Materials). (Brookhaven National Lab., Upton, N. Y.). (CAPE–1440).

6 drawings.

The chamber is used in a reactor or particle accelerator proton beam in studying fission at high energies and angular distributions. A target of $\frac{1}{32}$ in. Al has a deposit of 50 μg cm U. Solid state detectors mounted on the movable

arms detect the particles. The arms can be positioned remotely by electric motors. The equipment is contained in a vacuum chamber with thin windows of glass or plastic. The windows are used in alignment and for vacuum pumpout tubes. (For details, see TID-4100, Suppl. 36) (F.S.)

**361** PRESELECT CHASSIS FOR THE 10 Mc SCALER (Engineering Materials). (California Univ., Livermore. Lawrence Radiation Lab.). (CAPE-1490).

23 drawings.

A readout control unit is used in scaling operations where it is desirable to print out information from scalers to a digit recorder. The equipment is used with the Dual 10 Mc Scaler (see CAPE-1162). The circuit will simultaneously control (start, stop, reset) up to 4 scalers. The highly reliable circuitry utilizes silicon semiconductors and printed circuit boards. (For details see TID-4100 Suppl. 37) (F.S.)

## Radiation Effects on Instruments and Instrument Components

*Refer also to abstract 692.*

**362** COSMIC-RAY INDUCED DARK CURRENT IN PHOTOMULTIPLIERS. Young, Andrew T. (Univ. of Texas, Austin). Rev. Sci. Instrum., 37: 1472-81(Nov. 1966).

Čerenkov light flashes produced by cosmic rays traversing the window of an end-on photomultiplier create a fundamental noise limitation that cannot be reduced by cooling the tube. Although the cosmic ray pulse rate is only 1 or 2 $cm^{-2}$/min, the individual pulses may be hundreds of times larger than single electron pulses. Thus in d-c or charge integration photometry, cosmic ray noise can exceed thermionic dark current noise at temperatures as high as +10°C. These assertions are based on the observed behavior of EMI 6256 and 9558 tubes. The implications for photometry of faint astronomical sources are discussed. (auth)

**363** DISTURBANCE OF RECIPROCITY LAW IN γ-PHOTOGRAPHY. Gostishchev, V. S.; Terent'ev, R. A. Defektoskopiya, No. 3, 13-16(1966). (In Russian).

Disturbance of the reciprocity law in screened and unscreened x-ray film after exposure to $^{137}Cs$, $^{192}Ir$, and $^{170}Tm$ γ sources of 0.17, 1.5, and 0.41 g-equiv radium was studied. (R.V.J.)

**364** SCINTILLATION LIGHT YIELDS OF INORGANIC AND ORGANIC CRYSTALS FOR ENERGETIC DEUTERONS, α PARTICLES, AND ELECTRONS. Schoett, W.; Flammersfeld, A. (Univ., Goettingen, Ger.). Z. Naturforsch., 21a: 1075-80(July 1966). (In German).

The scintillation light yield S of three inorganic (NaI(Tl), KI(Tl), CsI(Tl)), of two organic (p-terphenyl, anthracene) crystals, and of plastic NE 102 by bombardment with deuterons in the energy range from 10.0 to 27.5 MeV, α particles from 8.0 to 55.0 MeV, and electrons was measured. The time constants of the electronic circuit were chosen to $\tau_1 = 0.5$ μsec and $\tau_2 = 2.0$ μsec. The pulse-height ratios $S_D/S_\beta$ and $S_\alpha/S_\beta$ are slightly different for the two time constants. The inorganic crystals have a higher pulse-height ratio for the short time constant, whereas the organic crystals and plastic show the inverse effect. (auth)

# LIFE SCIENCES

## Biochemistry, Physiology, and Molecular Biology

**365** (FSU–2690-31) GENERALIZED SUSCEPTIBILITY THEORY. I. ON THEORIES OF HYPOCHROMISM. Bulletin No. 31. Rhodes, William; Chase, Malcolm (Florida State Univ., Tallahassee. Dept. of Chemistry). Oct. 1, 1966. Contract AT(40-1)-2690. 72p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Thesis.

A general theory was developed for the linear response of an interacting molecular system to an external field. The exact ground state of the system is expressed in terms of the uncoupled molecule (zeroth-order) state by means of adiabatic time dependent perturbation theory. Including the external field to first order in the time development operator leads to an infinite-order expansion of the linear response function for physical quantities such as current-charge density and electric dipole polarization. Two basic approximations involving partial decorrelation of charge motion and spatial separability of the molecules allow the response function to be determined by a simplified Dyson-type equation, which can be put into closed form by further approximations. The approximate linear response function (susceptibility) so obtained is given in terms of the isolated molecule susceptibility and corresponds exactly to the results of classical, local field theory. Emphasis throughout is placed on the effect of molecular interaction on absorption spectra. Comparisons among theories of hypochromism show clearly that all previously reported theories are mutually compatible and are either equivalent to, or are contained in, the theory developed here. The relation of the present theory to a coupled equivalent oscillator model is discussed and the results are applied to a simple physical model. (auth)

**366** (UCB–34P23-1) DECONTAMINATION OF SOILS CONTAINING SALT AND RADIOACTIVE ELEMENTS. Annual Report, 1965-1966. Overstreet, Roy (California Univ., Berkeley. Dept. of Soils and Plant Nutrition). Sept. 1966. Contract AT(11-1)-34. 71p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Studies of two organic soils showed that the exchange complex is easily saturated with divalent cations such as $Ca^{2+}$ and $Sr^{2+}$. However, the calcium of the Ca saturated soils is only slowly exchangeable with $Na^{+}$ ion, even when the soils are leached with 1N NaCl solution. When the soils are leached with dilute NaCl, a portion of the adsorbed Ca or Sr appears to be nonexchangeable or extremely slowly replaceable with $Na^{+}$. The results indicate that as the exchangeable calcium percentage is reduced, the adsorbed $Ca^{2+}$ becomes increasingly more difficult to exchange with monovalent ions such as $Na^{+}$. This finding suggests that there exist many different forms of adsorbed Ca and Sr in these organic soils. Possibly complexing of Ca and Sr with the organic fraction occurs. A study of the variation of the $Ca^{2+}$ exchange capacity of peat soil with pH indicates that sites readily available to $Ca^{2+}$ and $Sr^{2+}$ but not to $Na^{+}$ are also readily available to $H^{+}$. That is, there is a marked dependence of the Ca exchange capacity on pH. The ion exchange studies show that Gapon's exchange equation describes the equilibrium conditions for the Ca–Na exchange over a wide range and that other equations do not. In a greenhouse experiment, Sr-85 was painted on the leaves of chamise, buckbrush, and oak plants. The amounts of the isotope appearing in the subsequent new growth (6 weeks) were measured. It was found that significant translocation of Sr-85 occurred in buckbrush where the final concentration in the new growth was found to be approximately 10 per cent of that in the treated old growth. The comparable translocation in chamise was about one tenth of that found in buckbrush. The smallest translocation of Sr-85 occurred in oak where the concentration found in the new growth was quite low. Further studies of the uptake of carrier-free Cs-137 by the lichen Ramalina reticulata confirmed the earlier observation that the uptake is greatly influenced by the calcium status of the tissue. That is, the adsorption of Cs-137 is greatest when the Ca content of the tissue is low. The Cs-137 uptake increases under anaerobic conditions. (auth)

**367** ACTION OF RADIATIONS ON THE CENTRAL NERVOUS SYSTEM. IV. CHANGES IN GLUTAMIC DECARBOXYLASE (GDC). Avellone, S.; Abbadessa, S.; La Grutta, G. (Univ., Palermo, Italy). Boll. Soc. Ital. Biol. Sper., 41: 1419-22(Oct. 31, 1965). (In Italian).

These experiments were aimed at clarifying the reason for the rise in γ-aminobutyric acid (GABA) in the brain of rabbits one to 12 hr after irradiation. The reason for increase in GABA synthesis was examined by assays of GDC in irradiated brain. The rabbits received 1000-R doses of x rays and samples of cerebral cortex, basal nuclei, and cerebellum were assayed for GDC activity four to 24 hr postirradiation. The enzyme was estimated by a manometric technique in brain homogenates. The basal GDC activity in brain tissue (expressed as $\mu l$ $CO_2$ per mg tissue per hr) was 0.391, 0.608, and 0.305 in the three parts of brain, respectively. At four hr postirradiation GDC activity increased about 40% in cerebral cortex, 15% in basal nuclei, and 35% in cerebellum. At 8 hr the values were ~35, 15, and 45%, respectively. At 12 hr postirradiation the enzyme activity in cerebral cortex increased to 45% while falling in the other brain samples, and by the 24 hr near-normal levels were reached. The part of brain (basal nuclei) with the highest concentration of GABA showed the least change in GDC activity. The results tend to support the concept that the postirradiation rise in GABA stems from elevated GDC activity. (BBB)

**368** ACTION OF RADIATIONS ON THE CENTRAL NERVOUS SYSTEM. III. CHANGES IN THE CONTENT OF γ-AMINOBUTYRIC ACID. Avellone, S.; Abbadessa, S.; La Grutta, G.; Ortolani, E. A. (Univ., Palermo, Italy). Boll. Soc. Ital. Biol. Sper., 41: 1415-18(Oct. 31, 1965). (In Italian).

This study was designed to examine changes in an important metabolite, γ-aminobutyric acid (GABA), of the central nervous system in rabbits receiving an x-ray dose of 1000 R. GABA was estimated spectrophotometrically one to 24 hr postirradiation in the cerebral cortex, basal nuclei, and cerebellum. The basal values of GABA in these three structures were 274, 292, and 245 μg/g. At one hr postirradiation the GABA concentration had risen 17.3, 4.6, and 14.7% in cerebral cortex, basal nuclei, and cerebellum, respectively. At 8 hr the increases were more pronounced: 32.8, 30.0, and 42.8%. At 12 hr they reached 54.3, 27.8, and 54.3%. By the 24th hr after irradiation the values had fallen to normal levels or below. On the basis of these results the cerebral cortex and cerebellum appeared to be more affected by irradiation than lower brain centers. It is suggested that irradiation may augment the activity of enzyme systems controlling the synthesis of GABA, particularly that of glutamic decarboxylase. (BBB)

**369** CHARGE DENSITY ON NATIVE AND ULTRAVIOLET-IRRADIATED MYOSIN A. Westley, Francis (National Bureau of Standards, Washington, D. C.); Kaldor, George; Cohen, Irving. Biopolymers, 4: 205-13(1966).

Dimensions of native myosin and myosin A subjected to uv irradiation for 60 min were calculated on the basis of previous data, and the net charge and charge density of native and uv-irradiated myosin A molecules were calculated on the basis of the electrophoretic mobilities,

measured at pH of 7.5, 4°C in different concentrations of myosin A solutions and extrapolated to zero myosin A concentration. The axial ratios (a/b) values were a/b = 74, a = 1880 Å, and b = 26 Å for native myosin A; a/b = 104, a = 3280 Å, and b = 32 Å for 60-min-uv-irradiated myosin A. Electrophoretic mobilities gave identical values of 3.2 (± 0.1) × $10^{-5}$ $cm^2$/v sec for both native and 60-min uv-irradiated myosin A. From the prior sedimentation and diffusion data, together with newly obtained electrophoretic data, the net charge Z and the charge density σ of native and uv-irradiated myosin A molecules were calculated from Henry's equation. The following results were obtained: for native myosin A, Z = 160 negative charges per molecule and σ = 22 coulombs/$cm^2$; for uv-irradiated myosin A, Z = 312 negative charges per molecule and σ = 20 coulombs/$cm^2$. The results provide an experimental demonstration that the electrophoretic mobility of charged solute particles is dependent upon the particle charge density and not on the absolute charge of the particle. (BBB)

**370** FREE-RADICAL PROCESSES IN GAMMA-IRRADIATED HOMOGENATES OF ANIMAL TISSUES. I. INVESTIGATION OF THE FREE-RADICAL STATES IN HOMOGENATES OF IRRADIATED TISSUES BY THE POLYMERIZATION METHOD. Koslov, Yu. P.; Urtile, S.; Tarusov, B. N. Nauchn. Dolk. Vysshei Shkoly, Biol. Nauk., No. 2, 85-9(1966). (In Russian).

The authors clarify several laws of the copolymerization of monomers (the amide of acrylic acid—AA) with the biosubstrate after gamma-irradiation, and establish possible centers of copolymerization. The material for the experiment consisted of homogenates of different organs of mice (brain, liver, spleen, and fatty tissue). The AA monomer was labeled with radioactive carbon. To the unlabeled AA was added AA-$C^{14}$ so as to obtain a 5% solution of AA with an activity of 1 microcurie (1 ml). The solution of AA prepared in this way was added to the homogenate in a 1:3 ratio. It was of interest to discover how the dose of gamma-irradiation affects the character of polymerization of AA in homogenates of different organs and their chemical components. It was found that the degree of polymerization depends on the nature of the irradiated homogenate. Polymerization proceeds most intensively in the homogenates of the brain and liver. The irradiation dose of 100 kr intensifies polymerization of AA in the brain homogenates by 69%, in the liver homogenate by 19%, in the spleen by 95%, and in the fat tissue homogenate by 50% relative to the control (unirradiated homogenate, where free-radical processes inherent in normal tissue also take place). (TCO)

**371** CHANGE OF PROPERTIES OF POTATO STARCH IRRADIATED WITH $^{60}$Co γ RAYS. Putilova, I. N.; Traubenberg, S. E.; Korotchenko, K. A.; Komar, V. P.; Zhbankov, R. G. (Technological Inst. Food Industry, Moscow). Prikl. Biokhim, Mikrobiol., 2: 133-8(1966). (In Russian).

Potato starch in sealed glass ampules was exposed to $^{60}$Co γ radiation at 1500 R/min. Doses of 18 to 94 megarads caused radiolysis with maximum effects noted at 47 to 56 megarads. Irradiation caused marked reduction of the molecular weight and formation of dextrin-like compounds. (C.H.)

**372** X-RAY INDUCED LABILITY OF DEOXYRIBONUCLEIC ACID MOLECULES. Kan, Jen-pao; Sheng, P'ei-ken. (Inst. of Biochemistry, Shanghai). Sheng Wu Hua Hsueh Yu Sheng Wu Wu Li Hsueh Pao, 6: No. 1, 81-6(Feb. 1966). (In Chinese).

The ultraviolet absorption value of an x rayed DNA solution was found to increase gradually after the cessation of irradiation and this phenomenon was explored in some detail. At dosage levels lower than 80,000 R, this effect became notably increased with increasing radiation dosage. Both the temperature and the salt concentration exerted a great influence on this effect. The higher the temperature or the lower the salt concentration, the more marked was the increase in the ultraviolet absorption value. It was of interest to note that the effect completely vanished at a salt concentration of 2M after incubation at 37°C. Results obtained with the aid of the formaldehyde reaction indicated that two types of hydrogen bonds may exist in irradiated DNA molecules, those directly broken upon x irradiation and those labilized but not broken by x rays, and it was the subsequent breakage of those labilized hydrogen bonds under definite experimental conditions that was responsible for the afore-mentioned ultraviolet absorption effect. Light scattering data suggested that x irradiation (80,000 R) resulted in a decrease in molecular weight of DNA from 6 × $10^6$ to 1 × $10^6$ and there was still a continuous degradation of irradiated DNA molecules accompanying the increase of ultraviolet absorption. (auth)

**373** LONG-TERM IN VIVO RETENTION OF $^{144}$Ce BY BEAGLES. Richmond, C. R.; London, J. E. (Los Alamos Scientific Lab., N. Mex.). Nature, 211: 1179 (Sept. 10, 1966). (LA-DC-7401).

Long-term in vivo retention studies were conducted in beagles to which a single 28 uc dose of carrier-free $^{144}$Ce as cerium chloride was administered. During the 1050 day experiment, gamma activity was measured 126 times in each dog with a whole-body counter. Data was processed on an IBM 7094 computer. Biological turnover of $^{144}$Ce was found to be extremely slow with an apparent biological half-life of about 10 yrs. Results are compared with ICRP data, and implications for man are discussed. (H.G.D.)

**374** $^{90}$Sr AND Ca EXCRETION IN URINE OF MAN. Czosnowska, Wanda (Inst. of Occupational Medicine, Lodz, Poland). Nukleonika, 11: 459-70(1966).

The calcium and $^{90}$Sr intake and excretion was studied under hospital conditions in 10 adult patients over a period of two weeks. The patients were divided into two subgroups according to composition of the diet and intake of calcium which on the average amounted to 1.3 and 0.79 grams per day, respectively. The average dietary intake of $^{90}$Sr in two subgroups was 28.8 and 16.7 pCi/day, respectively. The excretion of $^{90}$Sr and of calcium, when expressed as a percentage of intake varied in two subgroups, however observed ratio [($^{90}$Sr/Ca urine)/(Sr/Ca food)] was relatively constant at about 0.75. On the other hand in individuals the urine-food ratio varied systematically with calcium excretion rate in urine. (auth)

**375** ON THE DOMINANT CAUSE OF INDIVIDUAL VARIATION IN $^{137}$Cs BODY CONTENT. Liniecki, Julian; Karniewicz, Wieslawa; Spodenkiewicz, Teresa (Inst. of Occupational Medicine, Lodz, Poland). Nukleonika, 11: 455-8(1966).

From data on body burden and excretion of $^{137}$Cs by eight young healthy adults, approximate values of biological half-life of cesium (long term component) were calculated assuming state of, or close to, the metabolic equilibrium. Highly significant correlation between individual values of body burden and half-life was obtained, whereas no correlation was apparent of body levels with excretion–intake. It is postulated therefore, that individual variation in turnover-rate of cesium is mainly responsible for observed distribution of $^{137}$Cs in urban population, subsisting on similar source on marketed food. (auth)

**376** OBSERVATIONS ON THE EFFECT OF $D_2O$ ON ENERGY-LINKED REACTIONS OF THE MITOCHONDRION. Margolis, S. A.; Baum, H.; Lenaz, G. (Univ. of Wisconsin, Madison). Biochem. Biophys., Res. Commun., 25: 133-41 (Oct. 5, 1966).

The use of $D_2O$ as the solvent medium is shown to selectively inhibit certain processes in mitochondrial energy transfer. The rate and efficiency of energy-linked trans-hydrogenation between pyridine nucleotides and oxidative phosphorylation were measured in beef heart mitochondria. In the energy conservation pathways of mitochondria, the formation, utilization and breakdown of high-energy intermediates are inhibited to a similar degree. Several possible explanations for the inhibitory effect of $D_2O$ are discussed. (C.O.)

**377** RADIATION EFFECTS IN PECTINS. Dzamic, M. D.; Jankovic, B. R. (Inst. for the Application of Nuclear Energy in Agriculture, Belgrade). Int. J. Appl. Radiat. Isotop., 17: 561-6(Oct. 1966).

Irradiation of pectins by γ rays causes decomposition of the molecules, which is observed as an extensive decrease in the specific viscosity of the solutions. The molecular weight also decreases by a factor in the range of $10^2$. The decomposition is intensified when solutions of pectin in water are irradiated. In that case, considerable de-esterification of carboxy groups is also found. Solid pectins are more stable. The difference may be due to the radiolytic products of water. Irradiation of pectins increases their thermal instability, which is observed as a decrease of the activation energy for thermal degradation. A comparison of activation energies with values for other compounds with similar polysaccharide structures, suggests that in all such materials the mechanisms for thermal decomposition and for radiolysis are very similar. The results indicate a considerable sensitivity of pectins to γ-irradiation. This suggests that special precautions are required if it is desired to treat natural products, containing both pectins and water, with γ rays. (auth)

**378** PYRIDINE CO-ENZYMES AS ELECTRON SCAVENGERS IN IRRADIATED DRY PROTEINS. Singh, B. B.; Ormerod, M. G. (Atomic Energy Establishment Trombay, India. Royal Military Coll. of Science, Swindon, Eng.). Biochem. Biophys. Res. Commun., 25: 28-34 (Oct. 5, 1966).

The pyridine coenzymes, NAD and $NADH_2$, are shown to be efficient electron scavengers and interfere with the reactions of thermalized electrons with disulfide bonds in trypsin and bovine serum albumin γ-irradiated in the solid state at 77°K. They also reduce the yield of cystine radicals in trypsin at room temperature. The oxidized form was more effective than the reduced form, and the difference is ascribed to their relative reactivities towards the thermalized electrons. The observed protection of trypsin by NAD is attributed partly to electron scavenging by the additive. (C.O.)

**379** STUDIES OF THE SEX DEPENDENCE OF THE DISTRIBUTION OF RADIOACTIVE Ce IN THE RAT ORGANISM. Schmautz, E. Heidelberg, Univ., 1964. 21p. $2.00 Gmelin, AED-Diss. 64-1095.

Thesis.

The influence of sex on distribution and excretion of carrier-free $^{144}CeCl$ in rats after intravenous injection was studied. Cerium-144 retention in bones and kidneys and $^{144}Ce$ excretion in urine was found to be higher for male than for female animals. Retention in the liver was smaller. No influence of sex on liver excretion was observed. (Dissertation Abstr.)

**380** FEEDING PRACTICES AS A MEANS OF REDUCING THE CONCENTRATION OF FALLOUT $^{137}Cs$ IN COW'S MILK. Ward, Gerald M.; Johnson, James E. (Colorado State Univ., Fort Collins). Vienna, International Atomic Energy Agency, 1966, Preprint SM-75/23, 8p. (CONF-660711-8). ORAU.

From Seminar on the Use of Radioisotopes and Radiation in Dairy Science and Technology, Vienna.

Under conditions of heavy fallout in 1962 and 1963 the $^{137}Cs$ content of pasture and hay forage in Colorado was 10 to 20 times higher than feed grains and several times higher than corn silage. It was found that a transfer coefficient based on the percentage of daily dietary $^{137}Cs$ secreted per liter of milk was relatively constant for all cows and influenced effectively only by the type of feed and not by level of milk production. The transfer coefficient for rations containing mostly forage was found to be 0.24% and for a high grain ration 0.72%. Thus in 1962 and 1963 the milk concentration of $^{137}Cs$ could have been most effectively reduced by largely replacing forage with grain. If the difference in $^{137}Cs$ concentration between hay and grains is less than a factor of three, then milk levels can be reduced by feeding hay because of the lower transfer coefficient. The contamination was greatest in the spring and declined during the summer by factors of 10; thus hay harvested late in the season would also produce milk with much lower levels of $^{137}Cs$. Late-cut hay of low contamination and a low transfer coefficient resulted in the lowest milk levels. The lower transfer coefficient associated with high hay rations appears to be a combined effect of a greater quantity of indigestible fiber and clay particles which make fallout $^{137}Cs$ unavailable to the cow. Under conditions of world-wide fallout, controlled dairy feeding practices can have a profound effect on the level of $^{137}Cs$ in milk. (auth)

## Ecology

*Refer also to abstract 179.*

**381** CONCENTRATIONS OF $^{65}Zn$, $^{54}Mn$, AND $^{60}Co$ OBSERVED RECENTLY IN MARINE ORGANISMS OF THE EAST PACIFIC. Young, D. R.; Folsom, T. R. 13p. (CONF-631111-1). ORAU.

From International Symposium on Radioactive Contamination of the Human Environment, Hiroshima.

Sessile mussels and barnacles are convenient organisms for studying fallout distribution because of their high concentrating ability. Variations in the content of manganese-54, zinc-65 and cobalt-60 in the mussel, Mytilus californianus, collected at various points along the Pacific coast are tabulated. The content decreases toward the south. The content of zinc-65, manganese-54, and potassium-40 was measured in Mytilus taken from Scripps Pier on the open coast, from San Diego harbor and from a landlocked boat harbor. The highest values were found at Scripps Pier. The concentrations of manganese-54, zinc-65, cobalt-60 and potassium-40 in Mytilus of different sizes were studied, and no differences were found. Different organs of Mytilus were analyzed for manganese-54, zinc-65, cobalt-60, and potassium-40; the kidneys contained 50 times as much zinc-65 as the muscles. The biological decay rate of zinc-65 is being studied in two sessile organisms. (H.L.W.)

## Genetics and Cytogenetics

**382** MARKER RESCUE OF THE ADSORPTION PROPERTIES OF BACTERIOPHAGE T4 BY BACTERIOPHAGE T2. De Groot, D. (Univ. of Leiden). Antonie van Leewenhoek, J. Microbiol. Serol., 32: 17-24(1966).

Crosses of bacteriophages T4 and T2 in Escherichia coli B result in progeny phage with a distribution of about 90% phages with the T4 adsorption properties and 10% phages with the T2 adsorption properties. This phenomenon, called partial exclusion of T2 by T4, was studied by crosses made between uv-irradiated T4 and unirradiated T2 as a helper phage, with the aim of rescuing exclusion properties of T4 by T2. Suspensions of phage T4 in phosphate buffer were irradiated with uv light from a 30 W Hanovia lamp at a distance of 43 cm. A survival curve of T2 was run with each set of irradiations and doses were calculated as phage-lethal hits. Rescue of adsorption properties from uv-irradiated T4 by T2 revealed progeny phage with intermediate properties. Fourteen independent progeny phages, plating on E. coli B/2, were plated on several indicator strains and their adsorption properties were also studied with specific T4 antibodies. Two of these, plating on E. coli KS/4, were not inactivated by the T4 antiserum, and were T2 h without apparent T4 properties. The other 12 progeny phages did not plate on KS/4, and were inactivated, but at a slower rate than the parental T4. Their mean efficiency of plating on E. coli B/2 (0.83) was significantly lower than that of the parental T4. The efficiency of plating was positively correlated with the velocity of inactivation by T4 antiserum. The observations were explained by assuming that the progeny phages were recombinants of T4 and T2 loci for adsorption sites. Plating of these 12 progeny phages on several indicator strains showed that they were all rII mutants and all, except one,

were rI mutants too. In addition, two were tu and h[4], respectively. The condition for the appearance of multiple mutants might be a complementation by T2 of uv-damaged functions, which otherwise fail to induce the completion of the lytic cycle in monocomplexes of extracellularly uv-irradiated T4. (BBB)

## Health Physics and Safety

*Refer also to abstracts 98, 180, and 816.*

**383** (AD-640888) ON THE ANGLE AND ENERGY DISTRIBUTION OF PHOTONS PRODUCED BY A REAL AND TWO SIMULATED FALLOUT FIELDS. Garrett, C. W. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). July 1966. 37p. (AFRRI-SP-66-1). CFSTI $2.00 cy, $0.50 mn.

A qualitative discussion is given outlining the need to study radiation fields of military interest, noting the parameters involved in defining such fields, and describing some methods by which these parameters may be evaluated. A discussion of characteristics of the radiation fields for each of the following five geometries associated with fallout is presented: in air 3 feet above a fallout field; at the midpoint of a foxhole in a fallout field; in air 3 feet above the ground and 200 feet from a $^{60}$Co source; at the midpoint of a foxhole 200 feet from a $^{60}$Co source; and at the central point of a conceptual, compact, sophisticated fallout simulator. The latter three cases represent methods that might be employed to simulate the actual radiation fields as described by the first two cases. The simulated fields are qualitatively compared with their actual counterparts. (auth)

**384** (AHSB(RP)-R-14) POTENTIAL MAGNITUDE OF CRITICALITY ACCIDENTS. Woodcock, E. R. (Authority Health and Safety Branch, United Kingdom Atomic Energy Authority, Risley (England)). [nd]. 12p. Dep. mn.

Data on 24 criticality accidents are reviewed in an attempt to obtain a reasonable estimate of the potential magnitude of criticality that may be expected after the sequence of events that actually occur during excursions. From 23 of the accidents for which estimates are possible the yield has ranged from $3 \times 10^{15}$ to $1.2 \times 10^{20}$ fissions. Some of these accidents occurred in experimental laboratories and some in reactors. In process plant accidents the yield ranged from $1.5 \times 10^{17}$ to $4 \times 10^{19}$ fissions. Examples are presented of typical excursions resulting from a solution of fissile material entering a vessel which is unsafe by virtue of its shape, an influx of water leading to increased moderation, the concentration of a dilute solution by precipitation, or from subcritical pieces approaching each other. The effects of time delay, size of excursion in solid systems, and the shape of the energy release curve on the potential magnitude of criticality in systems in which the nuclear reaction results in a steady decrease of reactivity are discussed. The catastrophic system that may result in an explosion is also discussed. Applications of the data in plans for emergency actions in the event of a nuclear accident are presented. (C.H.)

**385** METHOD OF RECORDING EXPOSURE TO SOFT BETA-RADIATION WITH THE TISS RADIOMETER. Bonev, L. (Scientific Research Inst. of Radiology and Radiation Hygiene, Sofia). Rentgenol. Radiol., 3: No. 4, 65-9(1964). (In Bulgarian).

The circuits and arrangement of the TISS radiometer and procedure in measurement of exposure to radiation are presented. (JPRS)

**386** RADIOACTIVITY IN FRESH-WATER FISH. Ruf, M. (Univ., Munich). Zentralbl. Veterinaermed., 12: 605-12(Dec. 1965). (In German).

The increase in contamination of surface water with artificially produced radioactive materials makes it important to assess the degree of contamination of fresh-water fish because they may be a source of radionuclides when eaten by man. The total $\beta$ activity in muscle of cyprinoid fish varied from 2.0 to 3.7 pC/g fresh wt, and in salmonoids it varied from 2.7 to 3.8 pC/g. Most of this was due to $^{40}$K. In bones of these fish the range of values was 1.0 to 4.0 and 1.5 to 7.0 pC/g. The scales contained from 1.0 to 8.0 pC/g of $\beta$ activity. Most of the $\gamma$ activity found in fish muscle consisted of $^{40}$K, $^{137}$Cs, and $^{137}$Ba. The $^{137}$Cs activity amounted to ~3150 pC/kg. In cyprinoid fish muscle, the $^{90}$Sr activities varied from <1 to 12 pC/kg, but in bone it was between 28 and 510 pC/kg. The scales contained ~ the same amounts. In other samples of fish muscle $^{137}$Cs varied from 47 to 3150 pC/kg. Evidence for presence of $^{89}$Sr was also found. In muscle it was from <1 to 12 pC/kg, in bone it was from 13 to 300 pC/kg, and in scales, the $^{89}$Sr concentrations varied from 6 to 390 pC/kg. The degree of incorporation of the radioisotopes depended on a number of factors that could not be predicted. In addition to absorption with the food, absorption of radioactive Sr through the body surface seemed to play an important role in fish. (BBB)

**387** PARAMETERS DESCRIBING THE MICROSCOPIC DISTRIBUTION OF RADIATION DOSE. Bevan, John S. (Borough Polytechnic, London). Phys. Med. Biol., 11: 405-9(1966).

The fact that the Linear Energy Transfer (LET) of radiation has a marked effect upon the dose/response relationship for very many radiobiological effects has been known for a long time. On the macroscopic level, account has been taken of this and other variations in the relationship by the introduction of the concept of Relative Biological Effectiveness (RBE). Many RBE/LET experiments have either explicitly or implicitly assumed the validity of measurements based on $LET_\infty$ (where $LET_\infty$ = dE/dx, the stopping power) even although it has been acknowledged, at least since the work of Lea (1946) on $\delta$-rays, that some sort of track-core LET must be used. Partly as a result of the difficulties in a $\delta$-ray corrected LET approach, an alternative approach to quantifying the deposition of radiation dose on the microscopic level has been outlined and developed experimentally by Rossi (1959, 1960, 1962, 1964, 1966) and others (e.g. Rossi, Biavati and Gross 1961, Biavati, Rosenzweig, Rossi and Miyanaga 1963, Barendsen 1964 b, and Fowler 1964). The generality and usefulness of that approach is extended. The parameters introduced by Rossi for the quantification of energy deposition in small spherical volumes are discussed, and more general parameters, appropriate to the distribution of radiation dose in volumes of arbitrary shape, are defined. It is shown that the Rossi parameters can be regarded as a special case of the more general parameters. The application of these new parameters to cylindrical volumes is outlined, and a resulting definition of a long cylinder is suggested. (C.H.)

**388** DETERMINATION OF CERTAIN PARAMETERS OF THE REMOVAL OF NATURAL RADIOACTIVE AEROSOLS FROM AIR. Styro, B. L.; Verba, E. Yu.; Shopauskas, K. K. Izv., Atmos. Oceanic Phys. (Eng. Transl.), 1: No. 12, 763-8(1965).

A method is described for measuring the radioactivity of air in the free atmosphere and within cloud systems by filtering it through porous filters and sifting the droplets. Radioactivity samples were taken during an airplane flight by filtering air through an LFS-1 cloth with a density of 0.3 - 0.6 mg/cm$^2$. The air was drawn through an intake pipe jutting out at a distance of 0.5 m from the plane fuselage, bent at a right angle to the side of the plane and ending in a funnel. The theoretical basis of the technic is developed and formulas are derived for calculating the parameter A for nonradioactive removal of radioactive aerosols into cloud droplets. Two methods of determining A are suggested: by profiling the concentration of radioactive material in the cloud air and outside of it, and by disturbing the radioactive equilibrium between the decay products of radon in the cloud zone. Using A and data in the literature on the concentration of droplets in a cloud, the value of the coefficient K of coagulation of radioactive

aerosols into droplets was calculated. It averaged $3 \times 10^{-6}$ $cm^3/sec$. The coefficient K is used to study the mechanism of the capture of aerosols by droplets. (BBB)

**389** ROLE OF BONE MEAL AND TANKAGE IN THE FOOD CHAIN OF THE NUCLIDE $^{90}Sr$. Szulc, Marcin (Main School of Agriculture, Warsaw). Med. Weterynar. (Poland), 21: 284-7(May 1965). (In Polish).

Bone meal (50 samples) and tankage (50 samples) produced in 1963 was analyzed radiometrically. The total beta activity as well as the activity of the nuclide $^{90}Sr$ in these samples was determined. The results of the investigation show that both types of meal, particularly bone meal, had a fairly high contamination level. The total beta activity of bone meal was 12.7 pc/g; $^{90}Sr$ activity was 62.5 pc/g and 25.58 pc/g Ca. For tankage (meat-and-bone meal) the total beta activity was 11.6 pc/g and $^{90}Sr$ activity: 1.56 pc/g and 17.35 pc/g Ca. The addition of bone meal to the feedstuffs given to dairy cows caused a considerable rise in the level of $^{90}Sr$ in milk and meat. It is highly essential to produce artificial mineral mixtures rich in calcium, phosphorus, and other elements indispensable to the animal organism but totally free of $^{90}Sr$ and other radioactive isotopes. Such mixtures would lead to a natural decontamination of the animals. (JPRS)

**390** USABILITY OF FOAM EXTRACTION FOR THE DECONTAMINATION OF WATER. Oglaza, Jan; Siemaszko, Aleksander (Inst. of Nuclear Research, Warsaw). Nukleonika, 11: 421-7(1966). (In Polish).

The effectiveness of removal of $^{89}Sr$, $^{137}Cs$, and $^{144}Ce$ from water by foam extraction using five different surface-active agents was examined. The optimal parameters of this process were established. The usability of this method for the preliminary decontamination of the low and middle level radioactive wastes was stated. The method is interesting for large volume of radioactive effluent; the volume of the foamate, after foam disintegration, was about 0.1 to 1.0% of the volume of the decontaminated water. (auth)

**391** SOME CHARACTERISTIC ASPECTS OF THE PROBLEMS POSED BY THE CONSTRUCTION OF A REPROCESSING PLANT. Joly, Bernard; Jouan, Rene; Viennot, Jacques (Societe Saint-Gobain Techniques Nouvelles, France). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 60, 21-8(July-Aug. 1966). (In French).

The criticality dangers in a fuel reprocessing installation are reviewed briefly, and basic principles for the protection of personnel against radiation are indicated. The importance of the ventilation system and division of the plant into various activity zones is emphasized. Decontamination techniques are necessary in the case of mechanical incidents and leaks. The adaptation of classical chemical techniques to working conditions in an active zone is illustrated by clarification of solutions, transfer of liquids, and sampling. (J.S.R.)

**392** THE TRANSPORT OF IRRADIATED FUEL ELEMENTS IN FRANCE. Labrousse, M. M. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 60, 29-37 (July-Aug. 1966). (In French).

Regulations controlling the transportation of irradiated fuel elements are briefly summarized. The shipping containers necessary for various activity levels are described. (J.S.R.)

**393** PUBLIC HEALTH ASPECTS OF THE MEDICAL USES OF IONIZING RADIATION. Report on a Seminar Convened by the Regional Office for Europe of the World Health Organization, Lund, 4–9 October 1965. Copenhagen, Regional Office for Europe, World Health Organization, 1966. 48p.

The hazards to patients and medical personnel of exposure to ionizing radiations used for medical purposes are reviewed. The somatic, genetic, and leukemogenic effects of radiation are discussed and recent improvements in techniques and equipment leading to decreased exposure during dental and diagnostic radiography and radiotherapy using x radiation, $\gamma$ radiation, and sealed or unsealed radiosotopes are considered. Public health and legal aspects of radiation protection are also considered briefly. (C.H.)

**394** EXPERIMENTAL STUDIES WITH HeLa CELLS USING FAST ELECTRONS AND X RAYS. Marquardt, K. Goettingen, Ger., Univ., 1964. 44p. $2.00 Gmelin, AED-Diss. 64-1089.

Thesis.

The relative biological effectiveness (RBE) for irradiation of HeLa cells with 14.2 Mev electrons in comparison to 200 keV x rays is 0.75. (Dissertation Abstr.)

**395** ANALYTICAL QUALITY CONTROL AND MILK CONTAMINATION SURVEY. Merten, D.; Bergerhoff, G.; Ferraris, M. M. (International Atomic Energy Agency, Vienna). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-75/3, 16p. (CONF-660711-2). ORAU.

From Seminar on the Use of Radioisotopes and Radiation in Dairy Science and Technology, Vienna.

The assessment of hazards due to environmental contamination is based on results of analytical activities, i.e., qualitative and quantitative determinations of radioactive material in different matrices. A correct evaluation, therefore, requires the knowledge of the reliability of the relevant analytical data, mainly accuracy and precision which have to be determined by a regular and systematic analytical quality control. Precision can easily be determined by the individual laboratories themselves. Determination of accuracy, however, being indispensable for many purposes requires the analysis of standardized material or participation in intercomparison runs. A service covering both types has been, and is still being, offered by the IAEA under Project LOWRA including the following radionuclides and matrices: $^{131}I$, $^{90}Sr$, $^{137}Cs$, $^{210}Po$, $^{226}Ra$, Pu in milk, animal tissue and bone, vegetation and soil, respectively. The results obtained so far from intercomparisons reveal remarkable differences. Determinations of $^{90}Sr$ and $^{137}Cs$ were found to be satisfactory if carried out in medium concentration levels (about 500 pCi/kg) and less satisfactory if the radionuclides were present in concentrations of 20–50 pCi/kg. Determinations in extreme low-level concentrations (about 1 pCi/kg) were found to provide unsatisfactory results. Most probably, the wide spreads observed are caused by additive systematic errors of various types. The outcomings of these runs stress the need for improving internal and external analytical quality control in this particular field of applied analytics. (auth)

## Medicine

**396** RECOVERY EFFECT OF HETEROLOGOUS DEOXYRIBONUCLEIC ACID FROM VARIOUS ORGANS ON IRRADIATED MICE. Savkovic, N.; Kacaki, J.; Hajdnukovic, S. (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Nature, 211: 1179-80(Sept. 10, 1966).

The effects of heterologous DNA on survival of irradiated animals were investigated in mice exposed to x rays (600 R) just prior to intraperitoneal injections of DNA extracted from various tissues of rats of comparable age. Survival was 4% in the controls, and was increased by DNA injections to 53% for liver DNA, 54% for kidney DNA, 37% for thymus DNA, and 37% for testes DNA. Results show that heterologous DNA reduces the effects of irradiation by a factor of 9 to 13. Statistically the differences are highly significant ($P < 0.001$). (H.G.D.)

**397** ENDOCRINE DEPENDENCY OF PAPILLARY CARCINOMAS OF THE THYROID. Crile, George Jr. (Cleveland Clinic Foundation). J. Amer. Med. Ass., 195: 721-4(Feb. 28, 1966).

Nineteen patients with surgically uncontrollable metastases were treated by desiccated thyroid feeding. Twelve patients showed either regression of metastases or arrest of their growth for periods varying from 5 to 16 yr and averaging 11 yr. The cancers of seven remaining patients failed to respond to the treatment with desiccated thyroid

or to any other type of therapy and the patients died with progressive growth of their metastases. Only four of the 12 who had metastases that responded to treatment with desiccated thyroid received a cancerocidal dose of $^{131}I$, i.e., 100 mC or more. In none of these patients was there any shrinkage of metastases by use of $^{131}I$ until treatment with thyroid was started. Since suppression of the output of thyroid-stimulating hormone by feeding desiccated thyroid involves no serious side effect, it is preferable to treat papillary cancers in this way rather than by giving large doses of $^{131}I$. Fatal pulmonary fibrosis, leukemia, and development of anaplastic carcinoma in tumors of low malignancy may occur following treatment with $^{131}I$, so that large doses of $^{131}I$ were rarely given, even to patients whose tumors concentrated it. Cancers that are enough like normal thyroid to concentrate $^{131}I$ are almost always enough like thyroid to have their growth suppressed by thyroid feeding. There is therefore no advantage in initial treatment of metastases by $^{131}I$. The incidence of response to thyroid feeding is much lower in patients whose tumors do not concentrate $^{131}I$ than in those whose tumors do. There was a correlation between the age of the patient, history of irradiation for benign disease, and response of papillary cancer to thyroid feeding. Every patient who gave a history of having had radiation therapy for a benign condition and whose tumor appeared before the age of 37 had their metastases controlled by thyroid feeding. (TCO)

**398** BIOLOGICAL PROTECTION MECHANISMS OF RADIOPROTECTORS ON MAMMALIAN CELLS. VI. CYTOLOGICAL EFFECTS OF SEROTONIN ON TUMOR CELLS, BONE MARROW, AND THYMUS CELLS. Kobayashi, Jindo; Yoshizaki, Tsutae; Kitajima, Tamio; Kawamura, Fumio (Tokushima Univ., Japan). Tokushima J. Exp. Med., 12: 45-50(May 1965).

Intraperitoneal injection of serotonin (2 to 5 mg/100 g) was made in tumor-bearing Wistar rats on the 4th day after transplantation of MTK sarcoma III. Within one to 6 hr after drug administration the mitotic rate increased. The relative frequency of ana- and telophase cells decreased, with a marked increase of prophase cells at one hr and an increase of metaphase cells at 6 hr after administration of serotonin. The mitotic rate returned to normal at 12-24 hr without dipping below the normal value. In treated bone marrow cells, prophase cells were increased at one hr and then decreased at 3 to 4 hr, while the metaphase cells decreased 1 hr after treatment and then increased at 5 to 6 hr. In thymus cells of mice treated at 3 mg/25 g of body weight, a temporary rise above the normal mitotic rate occurred at one hr which gradually returned to the normal value in 12 to 14 hr. In the samples taken from one to 6 hr after treatment, the relative frequency of prophase cell increased, while a decrease of metaphasic cells occurred at one hr. Metaphasic cells increased at 6 hr after treatment. One of the mechanisms of radioprotection in animals treated with serotonin may be the acceleration of cell division in normal tissues. (TCO)

**399** RADIOMETRIC MEASUREMENT OF SKIN TEMPERATURE CHANGES DURING SIMULATED NUCLEAR THERMAL RADIATION. Kaufman, William C.; Pittman, James Jr. Res. Technol. Briefs, 3: No. 7, 1-6 (July 1965).

A practical radiometer has been designed and constructed which allows measurement of skin temperature during exposure to intense thermal energy. Experiments were performed to determine the nearest safe distance from an exploding nuclear device for a man behind a plexiglass canopy. Subjects reported painfully hot sensations when skin temperatures reached 41.5 to 43.5C. This is 1.5 to 3.5C below the true pain threshold and the temperature causing skin burns. Significantly greater amounts of this spectrum of energy were required than have been previously reported. Results of this experiment indicate the nearest safe distance may be reduced to 50 to 70 percent of that indicated in some previously published literature but the thermal responses of cockpit components may establish limits of exposure shorter than those which can be safely tolerated by the human subject. (auth)

**400** RADIOTHERAPY AND BRONCHIAL CANCER. VIII. RADIATION REACTIONS IN THORACIC STRUCTURES AFTER RADIOTHERAPY OF BRONCHIAL CANCER. Piazza, G.; Conte, G. (Univ., Padua, Italy). Radiaz. Alta Energ., 3: 101-12(Apr. 1964). (In Italian).

Sequelae of pulmonary irradiation for bronchial carcinoma, particularly as seen by lung radiography, are examined with reference to 35 cases, mostly with pulmonary fibrosis. The acute stage of the pulmonary reaction was characterized by fever, dyspnea, and hemoptysis. At this stage, radiography revealed discrete striations in the lungs, which became more pronounced as fibrosis developed. However, at this stage, in some cases, the lung changes are reversible and may resolve leaving only minimal residual lesions. Exudation at this stage may lead to atelectasis. Transudation of the alveoli and impairment of the capillary circulation may be involved in this development. Formation of a hyaline membrane in the alveoli as a result of impaired fibrinolysis may also be noted after relatively low doses (1500 to 2000 rad of $^{60}Co$ $\gamma$ radiation). Fibrosis of the lung as seen radiographically is accompanied by increasing dyspnea and nonproductive coughing, sometimes with chest pain. Angiopneumonography can be used to demonstrate constriction of the pulmonary artery and smaller vessels in these cases. One case developed severe constriction of the esophagus after 2500 RAD treatment. (BBB)

**401** RADIATION-PROTECTIVE PROPERTIES OF NITRO-N-PHENYLBENZAMIDENE ADMINISTERED INTRAVENOUSLY AND ORALLY. Baev, I. Rentgenol. Radiol., 3: No. 4, 37-41(1964). (In Bulgarian).

Experiments were carried out on 180 albino rats to establish the radiation-protective properties of nitro-N-phenylbenzamidine by intravenous and oral administration. The radiation-protective properties are preserved by intravenous administration to a degree equal to that achieved by intraperitoneal application, but oral administration had no protective effect. (JPRS)

**402** VALUE OF ISOTOPIC RENOCYSTOGRAMS FOR SURGICAL ORIENTATION IN DISEASES AFFECTING THE URINARY SYSTEM. Augustin, Al.; Martinovici, I.; Wasserstrom, V.; Pop, T.; Grigorescu, C.; Herscovici, H.; Marinescu, I. Rev. Sanit. Mil., 61: 367-73(May-June 1965). (In Rumanian).

A description is presented of a simple, rapid, and safe method of obtaining radioactive isotope renal cystograms through the use of radioactive Hippuran in conjunction with an Orion renocystograph. Experience with 117 patients formed the basis for the refinement of technique described. This method involves 100 times less radiation for the patient than ordinary radiography of the urinary system. (JPRS)

**403** FUNCTIONAL EXPLORATION OF THE KIDNEY WITH THE AID OF ISOTOPIC NEPHROGRAMS IN IRRADIATED AND BURNED ANIMALS. Popescu, Gh.; Cavulea, O.; Bergheanu, S.; Wasserstrom, V.; Herscovici, H. Rev. Sanit. Mil., 61: 981-6(Nov.-Dec. 1965). (In Rumanian).

Studies involving 20 dogs showed that the radioisotopic method for the study of renal affliction is well tolerated by the animals, rapid, and relatively accurate. In irradiated dogs without burns, no changes in renal functions were noted by this method; third degree burns over 10 percent of the body surface aggravated the evolution of irradiation disease, with an early disturbance of renal functions. (JPRS)

**404** SIMULATION OF RADIOISOTOPE SCANS BY COMPUTER. Pizer, Stephen M. (Massachusetts General Hospital, Boston). Commun. ACM (Ass. Comput. Mach.), 9: 358-62(1966).

To improve the diagnostic effectiveness of scanning devices used with $\gamma$-emitting radioisotopes, it is important to improve the sensitivity and resolution of the scanner and to reduce background noise. It was considered of interest, as an aid in the development of improved scanning devices, to establish optimal scanning patterns by a com-

puter program. To study the output of scanners with various characteristics, a program which simulates radioisotope scans was written for a PDP-1 computer with auxiliary disk storage and cathode ray tube display. Past and present research using the output of the simulator has shown the flexibility of the system to be important. The program is divided into two parts: the discriminator and the simulator. The discriminator reads the input pattern by dividing the scan area into a number of elements and labeling each element in one of a number of ways and digitizes it according to its geometrical position with respect to the pattern. The simulator uses this digitized pattern to produce a scan. An important factor is the flexibility of the simulator. The scanner simulator has been used in a large variety of ways and for different purposes. This flexibility is to a large extent due to the separation between the discriminator and simulator stages. In the former the geometry of the target is described and put into matrix form. In the latter a model of the system being simulated is used to process the geometric information obtained from the discriminator. (BBB)

**405** COMBINED APPLICATION OF A CHEMICAL PROTECTIVE MIXTURE OF CYSTAMINE AND AMIDINE AND TRANSPLANTATION OF BONE MARROW IN EXPERIMENTAL RADIATION SICKNESS. Robev, S.; Zografov, D.; Baev, I. (Inst. of Radiology and Radiation Hygiene, Sofia). Eksp. Med. Morfol., 4: No. 1, 71-5(1965). (In Bulgarian).

The treatment of radiation sickness by the combined application of a chemical protective mixture of cystamine and amidine and transplantation of bone marrow proved very effective. An explanation of the mechanisms requires further work. (auth)

**406** RADIUM SOURCE APPLIANCE FOR TREATMENT OF NASOPHARYNGEAL CANCER. Rudd, Kenneth D.; Green, Allan E. Jr.; Morrow, Robert M.; Hancock, James A. Jr. (Lackland Air Force Base, Tex.). J. Amer. Dent. Ass., 72: 862-6(Apr. 1966).

Construction of a radium applicator is described. It offers the advantages of biological acceptability and patient tolerance; accurate location of the radium to insure proper dosage; minimal exposure of normal tissues to radiation by shielding, distance, and isolation; minimal discomfort and ease of removal and insertion, and minimal exposure of medical personnel to radiation. In the instance reported, the appliance was constructed for a patient who had a nasopharyngeal malignancy. Cobalt-60 irradiation had been given for carcinoma of the nasopharynx, in 6 weeks 5500 rad to the nasopharynx by multiple fields (lateral and anterior oblique). Sixteen months after this radiotherapy, a small granular mass was found in Rosenmuller's fossa on the left side, revealed to be recurrent transitional cell carcinoma. Since the patient had received the max amount of external irradiation, the recurring tumor was treated internally by radium needles. A dose of 4000 rad was given to the left nasopharyngeal fossa via the appliance. Three 10-mg radium needles with a dia. of 1.5 mm and an active length of 15 mm were mounted in a contour-fitting acrylic resin appliance. Holes, slightly larger than the radium needles, were drilled parallel to each other in the appliance and were positioned to provide the desired distribution of the radiation. The needles were secured with a resin disk, which enabled the radium needle-holding appliance to be loaded rapidly by the radiologist behind a protective screen and prevented accidental release of the radium needles. (BBB)

## Radiation Effects on Animals

**407** (NP-16353) LEUKAEMIA AND APLASTIC ANAEMIA IN PATIENTS IRRADIATED FOR ANKYLOSING SPONDYLITIS. Special Report Series No. 295. Court-Brown, W. M.; Doll, R. (Medical Research Council, London (England)). Apr. 18, 1957. 142p. Dep. mn. BIS $2.10; HMSO 10s. 6d.

The case records have been studied of 13,352 patients presumed to have ankylosing spondylitis and given x ray treatment at 81 British radiotherapy centers between 1935 and 1954. A diagnosis of leukemia, aplastic or hypoplastic anemia or myelofibrosis was recorded on the death certificates of 46 of the patients who had died by December 31st, 1955. In 28 of these patients death was certified as attributable to leukemia; in 12 it was certified as attributable to aplastic anemia. Details of x ray dose were obtained from a sample of approximately one in six patients, and the doses were expressed in terms of dose to the bone marrow in the spinal column and also in units of whole-body integral dose. The man-years at risk has been determined by estimating the population at risk for each level of dose from the sum of the number of years the patients have survived after receiving that dose and before they have received additional treatment. The dose-response relationship appeared to be linear when the relevant cases of leukemia were related to the man-years at risk following various levels of mean spinal marrow dose for the group of patients receiving only spinal irradiation and when all cases of leukemia were related to the man-years at risk following various levels of maximum spinal marrow dose for all patients. The dose-response relationship appeared to be curvilinear when all cases of leukemia were related to the man-years at risk following various levels of mean spinal marrow dose for all patients and when all cases of leukemia were related to the man-years at risk following various levels of whole body energy-absorption for all patients. For all patients, the annual incidence rises to 72 cases per 10,000 men following a mean dose to the spinal marrow in excess of 2,250 R. (TCO)

**408** (RLO-1781-6) THE STUDY OF IRRADIATION EFFECTS ON THE HUMAN TESTIS: INCLUDING HISTOLOGIC, CHROMOSOMAL, AND HORMONAL ASPECTS. Progress Report, June 1963–March 1966. Paulsen, C. Alvin (Washington Univ., Seattle. School of Medicine). Contract AT(45-1)-1781. 46p. ORAU.

The gonads of 31 men were exposed to acute doses of x radiation ranging from 7.5 to 400 R to the midplane of the testes. The effects of radiation on gonadal function were followed for 400 days by means of sperm counts before and after irradiation. Results showed that 15 R was the lowest dose that caused a reduction in sperm count. Men exposed to 50 R demonstrated a return to normal sperm count levels by 350 days following exposure. Testicular biopsy caused a significant drop in sperm count that was transient in nature in most subjects but persisted up to 400 days in some subjects. Testicular biopsy tissue examinations revealed that 100 R x radiation caused immediate damage to germ cells and cellular metabolism was shown to be altered 4 hr following exposure. Plasma testosterone levels did not change significantly after exposure in the dose range from 15 to 400 R, and no significant changes in estrogen excretion were observed. Urinary gonadotrophin excretion increased 30 to 135 days following irradiation, which was generally the period when the sperm count decreased. Leydig-cell hormonal production, as assessed by plasma testosterone measurements and urinary estrogen excretion assays, showed no significant changes after irradiation. Chromosome analysis of testicular tissue cultures showed that after exposure to 100 R there was a significant increase in both stable and unstable chromosome aberrations but no chromatid changes were observed. (36 references.) (C.H.)

**409** BLEEDING DEATH PRESUMABLY DUE TO TELANGIECTASIS OF THE BLADDER FOLLOWING $^{60}$Co THERAPY. Mori, Yukio; Hara, Takeshi (Mie Prefectural Univ., Japan). Hinyokika Kiyo, 12: 185-7(Feb. 1966). (In Japanese).

Two cases are reported of hemorrhagic death caused by bladder telangiectasis that developed as a late effect (one to two years) of cobalt-60 teletherapy. (TSS)

**410** LAW FORUM. Regan, William A. Hosp. Progr., 46: 19-24(Dec. 1965).

Medical data and legal proceedings are described in a case of x-ray overexposure of the hand in treatment of a benign disease, with a court award of $30,000 for malpractice. The patient, afflicted with warts on the back of his left hand, was treated by x rays at St. Francis Hospital, Evanston, Ill. In the first treatment a portion of his left hand was exposed to 750 R. Another portion of the left hand was exposed a month later (750 R). The third treatment took place a month later, because the warts treated the first two times were beginning to return. The record showed that the patient was administered 1025 R over a period of five min. The plantiff testified, however, that he was alone in the treatment room 10 min when the third treatment was given, which would have resulted in an exposure of 2050 R. Within a week after the third treatment, the skin in the area exposed during the third treatment became red and tender to the touch. A few days later the area swelled and opened up, secreting fluid. At the time of the trial, the patient still suffered from the periodic swelling and fluid secretion in that area. The medical experts called in the case said the injury could have been caused by an overexposure to x ray. As to what would constitute an overdose of x rays, all testimony was to the effect that an exposure lasting five min with a dose of 1025 R would conform to the acceptable standards of medical practice. A medical witness called in behalf of the defendant radiologist testified on cross examination that a dose of 2050 R over a period of 10 min would not have caused the patient's injury. The witness testified that he had given such a dose many times without ill effects. The defendant radiologist, on the other hand, stated that giving a dosage of 2050 R would be taking an undue chance. He pointed out, however, that patients have been given such dosages with no aftereffects. The trial court jury returned a verdict for the plaintiff in the sum of $30,000. (BBB)

**411** BRAIN INJURY AT VARIOUS PERIODS AFTER RADIOTHERAPY. Gzelishvili, M. S. Izv. Akad. Nauk Azerbaidzh. SSR, Ser. Biol. Nauk, No. 6, 125-31(1966). (In Russian).

Patients receiving radiotherapy for breast or lung cancer were examined from 1-16 years later. Symptoms of organic lesions of the central nervous system were anisocoria, horizontal nystagmus, central paresis of the facial and hypoglossal nerves, diffuse decrease in muscle tone, pathological reflexes, etc. Such involvement when combined with neuroinfection resulted in an atypical clinical course of the nosological forms. The symptoms of CNS involvement appearing some time after radiotherapy for malignant neoplasms were indicative of the diffuse nature of the pathological process. They developed after impairment of autonomic regulation and hemopoietic changes. Differential diagnosis as between brain injury and metastatic tumor of the brain is sometimes quite difficult. In some cases only prolonged observation can lead to the correct diagnosis. One of the long-term sequelae is epileptic seizures accompanying the symptoms of impaired autonomic regulation and sometimes hemopoietic changes. (auth)

**412** QUANTITATIVE CHANGES OF URIC ACID CONCENTRATION IN THE BLOOD OF RATS AFTER IRRADIATION WITH $^{60}$Co. Zamurovic, D.; Mandic-Zecevic, V. (Univ., Belgrade). Arh. Farm. (Belgrade), 15: 457-62(1965). (In Croatian).

An investigation was performed on 82 albino rats irradiated with doses of 600-1100r. Changes occurring after 5-120 minutes, 24 hours, 48 hours, 5 days, 15 days, 30 days subsequent to irradiation are presented in the tables. (auth)

**413** EFFECT OF MULTIPLE IRRADIATION BY AN INTERMITTENT CURRENT OF ULTRAVIOLET RADIATION ON THE HIGHER NERVOUS ACTIVITY OF WHITE RATS. Krivova, A. A. (Kharkov Medical Inst.). Fiziol. Zh., Akad. Nauk Ukr. RSR, 12: 447-51(1966). (In Russian).

The effect of cyclic, intermittent uv irradiation in biological doses of 0.1 and 1.0 (mercury quartz lamp) was studied on 24 male rats aged 2-3 mos. Conditioned-reflex activity was studied using the Kotlyarevskiy method (motor-food reflexes). It was found that the degree and nature of changes in higher nervous activity depended on the radiation dose and regimen. Intermittent irradiation (biological dose of 0.1) caused a greater shift in conditioned-reflex activity than continuous irradiation. A 0.75/0.75 (duration/interval, sec) regimen caused a depressed excitatory process to intensify. A 1/1 and 5/15 regimen caused an opposite effect. After the third exposure to uv, conditioned-reflex activity deteriorated, as reflected in a disrupted interplay between neural processes characterized by decreased excitability and increased lethargy. (TCO)

**414** FREE LIENAL AND HEPATIC AMINO ACIDS IN RATS GAMMA-IRRADIATED WITH $^{60}$Co. Mandic-Zecevic, V.; Avramov, R.; Zamurovic, D. (Medical Coll., Belgrade. Coll. of Pharmacy, Belgrade). Arhiv Farm. (Belgrade), 15: 263-71(1965). (In Croatian).

Results are given of a study in 26 rats receiving whole-body irradiation at age 3.5 months; thin-layer chromatography of arginine, histidine and lysine in liver and spleen extracts of a control group and of experimental rats. In general, all 3 of these acids showed an increase after irradiation. Five tables; 3 Western and 2 Yugoslav unpublished references. (auth)

**415** CYTOMORPHOLOGICAL INVESTIGATION OF BONE MARROW IN COCKS IRRADIATED WITH X RAYS. Rusov, C.; Gligorijevic, J. (Inst. for Application of Nuclear Energy in Agriculture, Veterinary Medicine, and Forestry, Belgrade). Acta Vet. (Belgrade), 15: 233-9 (1965). (In Serbian).

Seventy-four cocks of White Rock breed, 12 months of age, were used for the investigations. Single and total irradiation was carried out with 400, 600, and 1200 R. Bone marrow was taken by puncturing the proximal part of the tibia. It was found that the syndrome of radiolesions is characterized by changes in proliferation processes, and differentiation and maturation of bone marrow cells. Regeneration of bone marrow after irradiation occurs gradually, first with lymphocyte cells, then followed by monocyte and myeloid cells. The cells of erythrocyte generation, regardless of maturation degree, are relatively radioresistant to the applied doses of x rays. (auth)

**416** MODIFICATIONS OF SERUM $\gamma$-GLOBULINS IN YOUNG GUINEA PIGS SUBJECTED TO IRRADIATION AND SUBSEQUENT ADMINISTRATION OF THYMUS EXTRACTS. Marchese, G. S.; Mignone, F.; Cocuzza, S. (Univ., Turin). Minerva Pediat., 17: 794-7(Apr. 14, 1965). (In Italian).

A considerable decrease of serum gamma globulin was observed after radiation of the thymus gland. The decrease was evident after application of 250 R, and after 500 R was demonstrated even more clearly. In order to confirm the thesis concerning the correlation between gamma globulin percentage and thymic function, a few irradiated guinea pigs were treated with fresh thymus extract when an increase of the gamma globulin fraction was obtained. Because of these results the existing correlation between the thymus gland and serum gamma globulins, or between thymus gland and the immunity system, is emphasized. (H.L.W.)

**417** TOLERANCE TO CRITICAL ACCELERATION AFTER EXPOSURE TO IONIZING RADIATION. Davydov, B. I. Dokl. Akad. Nauk SSSR, 168: 691-3(May 21, 1966). (In Russian).

The reaction of the irradiated organism to critical accelerations was studied using 1690 male mice. The reaction of the animals was evaluated as a function of their viability after exposure to radial accelerations of 42 to 44 G on a centrifuge with an arm radius of 0.31 mm. The force vector was in a back-to-chest direction. Prior to acceleration, the animals were irradiated with $^{60}$Co gamma rays in doses ranging from 100 to 4000 R (13 to 18 R/min). Exposure to acceleration took place from 1 to 45 days after

irradiation. It was found that 42 to 44 G caused the death of 40 to 50% of the control animals. Deviations from this percentage reflected altered acceleration stability on the part of irradiated animals. Starting with the first and second day after irradiation, the tolerance of irradiated mice to acceleration was higher than controls. From the eighth day on, acceleration tolerance decreased. Decreased tolerance during this period corresponded to the onset of radiation mortality. Increased tolerance to acceleration was noted 1 to 6 days after 200 to 4000 R irradiation. Later (9 to 45 days), the reaction of mice irradiated by less than 7000 R was studied and it was noted that lowered tolerance to acceleration was maintained up to the 45th day (after irradiation by 200 R). The relationship between irradiation dose and acceleration tolerance equivalent to the control value, calculated by a method of extrapolation-interpolation is given. One reason for the increased tolerance of irradiated animals to acceleration may be shifts in the blood coagulation system and cell membrane permeability occurring during given periods of radiation sickness which possibly create better hemodynamic conditions during acceleration. (auth)

**418** INVESTIGATION OF LYMPHOCYTE PRODUCTION IN GUINEA PIG BONE MARROW. Harris, P. F.; Kugler, J. H. (Univ. of Sheffield, Eng.). Acta Haematol., 33: 351-69(June 1965).

Marrow was labeled with $^{3}H$-thymidine and then cultured in the peritoneal cavity of a host whose own lymphocyte levels and production had been grossly suppressed by previous irradiation in the supralethal range. Various doses of x rays were given to male guinea pigs of the Dunklin-Hartley strain. Results indicated that lymphocytes are produced in guinea pig bone marrow. During recovery from irradiation there were numerous telophases in marrow smears which led to formation of small lymphocytes. Moreover, many lymphocytes were still found in shielded bone marrow after the rest of the body, including the conventional lymphoid tissues, had received lethal or supralethal irradiation. Almost 50% of these cells were formed after irradiation. An unexpected finding was that the total nucleated cells in shielded marrow are considerably reduced. This occurs despite efficient shielding of the limbs. The reduction is too great to be explained by hemopoietic depression following the small dose of scatter irradiation which the shielded marrow received. Probably this marrow was subjected to excessive functional demands which were usually discharged by a much larger volume of marrow. (TCO)

**419** STUDIES IN NORMAL CHILD DEVELOPMENT. Best, J. (Peter MacCallum Clinic, Melbourne). Radiographer, 12: 18-26(Dec. 1965).

Radiographic studies of bone development in normal children are reported, with data on protective measures used. Also included are radiographs showing retardation and maldevelopment caused by ionizing irradiation of growing bones of humans and animals. In the radiograph of an eight-year-old-boy survivor of the atomic bomb explosion on Hiroshima, a line is noted across the shaft of the radius that is ascribed to a temporary interruption of the growth process caused by irradiation and other injuries during the time of the atomic bombing. X-ray photographs are also shown of young rats, whose tails were irradiated with differing doses. There was a decided difference in bone structure between the tails of the rats which had been irradiated and those which had not been irradiated. There was more striking appearance. Some radiographs are illustrated to demonstrate bone injury in children in the early days of radiotherapy. After radiotherapy of an angioma on a boy's right arm at a very early age, radiographs of the hands and forearms of the boy at 12 yr of age showed that although the right limb is markedly smaller than the left, the epiphyses match those of the left in bone age and general development. The case demonstrates interference to the growth in size of the bones, without undue hindrance to bone age development. Another radiographic example shows the hand of an 18-yr-old youth, who, as an infant, was treated with radiotherapy for keloids. All the bones of the right hand are miniatures of those of the left. (TCO)

**420** GENETIC RADIATION SUSCEPTIBILITY OF HAMSTERS (MESOCRICETUS AURATUS). Baev, I. (Scientific Research Inst. of Radiology and Radiation Hygiene, Sofia). Rentgenol. Radiol., 4: No. 1, 21-5(1965). (In Bulgarian).

The genetic susceptibility of hamsters to radiation was tested, utilizing embryonic mortality and anomalies caused by x irradiation of their spermatozoids. Local irradiation of the gonads with doses of 320, 400, 560, 720, and 800 R was applied and $LD_{50}$ was estimated to be 464 R. (JPRS)

**421** EFFECTS OF A SINGLE DOSE OF WHOLE-BODY IRRADIATION ON THE SYNAPSES OF THE SPINAL CORD OF MOUSE. Hu, Jen-i. Chieh Pou Hsueh Pao, 9: No. 1, 30-8(Feb. 1966). (In Chinese).

The present work deals with morphological changes of the synaptic structures in the spinal cord of adult mice after a single dose of x irradiation. The animals used in this study consist of 22 male albino mice weighing from 25 to 30 grams. Total exposure of the mice to a single dose of 500 R x irradiation was made under the following conditions: 180 Kv, 10mA, a radiation rate of 33 R/min at a distance of 30 cm, filter 1.0 mm. Al + 0.5 mm Cu. The animals were killed at 1, 2, 5, 7, 19, 33 days after the treatment with 3 mice in each group. Four normal animals were used as control. Cervical segments were removed from the spinal cord stained with Golgi-Deineka method. Sections were cut at 10-15 $\mu$. One day after irradiation, signs of the injured synaptic structures were visible in the cervical spinal cord as slight swelling of the ring-like boutons. The injured boutons increased in number from the second day onward with further changes in shape and size. The majority of them together with presynaptic fibres showed further swelling and were darkly impregnated. During the last stage of post irradiation, most of the injured boutons underwent disintegration and appeared as granules while some others were gradually returning to normal. It is considered that synapses in the spinal cord of the mice, were much more radiosensitive than they are thought to be. (auth)

**422** EFFECTIVENESS OF SEROPROPHYLAXIS OF ERYSIPELAS IN X-IRRADIATED ANIMALS. Gorbatov, V. A. (All-Union Inst. of Experimental Veterinary Medicine, USSR). Dokl. Vses. Akad. Sel'skokhoz. Nauk, No. 10, 33-7(Oct. 1965). (In Russian).

The effectiveness of seroprophylaxis of erysipelas is related to the irradiation dose. A single injection of 0.03 ml of antierysipelas serum, which ensures 100% protection of control mice against an absolutely lethal dose of Bacterium rhusiopathiae suis, proved to be ineffective in protecting mice irradiated with 200 R or larger doses. Six to eight times more of the immunizing preparation was needed to create stable passive antierysipelas immunity in control animals during the period of acute development of radiation sickness. Normal immunological reactivity in the formation of passive antierysipelas immunity was restored in the mice 2 to 3 months after exposure. (JPRS)

**423** CONDITION OF THE NEURAL ELEMENTS OF THE DOGS' TONGUE DURING EXPERIMENTAL RADIATION SICKNESS. Abduraimov, D. A. Nauch. Tr., Samarkandsk. Med. Inst., 29: 61-6(1964). (In Russian).

Experiments were conducted on dogs which were subjected to a single total body x ray irradiation in a dose of 300 R. It was determined histologically that all nerves of the tongue are affected in dogs during radiation sickness. The destruction both of the sensory nerve endings and of the motor end-plates was revealed. It was observed that not all of the nerve fibers and their endings are subject to changes. A portion of them remains intact. (JPRS)

**424** ON THE UP-TAKE OF TRITIATED THYMIDINE BY $^{60}Co$-IRRADIATED MOUSE BONE-MARROW CELLS TREATED WITH HOMOLOGOUS BONE MARROW.

Ichikawa, Y. (National Inst. of Health, Tokyo). Bibl. Haematol., 23: 234-8(1965).

A method was devised to trace homologous transplanted donor cells in the bone marrow of lethally irradiated mice. A preliminary test was performed to determine the survival rate of mice infused with homologous bone marrow cells after 1000 R irradiation. Recipients were 8-week-old female dds strain mice and donor mice were $C_{57}$ BL/6 strain female. The donor cells ($8 \times 10^6$ nucleated cells) were given in the tail vein 24 to 48 hr after irradiation with 1000 R from a $^{60}Co$ source. A survival rate of 70% was seen when transplantation was given after irradiation. All mice which received only irradiation died within 10 days and their bone marrow and spleen tissue showed marked histological changes. However, the bone marrow of recipient mice showed colonies of healthy cells 7 to 10 days after transplantation. An attempt was made to determine whether these cells were from the recipient of donor marrow cells. Twenty $\mu C$ of $^3H$-thymidine was injected intraperitoneally and 72 hr later a bone marrow sample was obtained and a smear prepared. When the percentage of labeled cells was calculated, it was found that in normal mice 20 to 30% of the cells in the bone marrow had taken up thymidine, and in mice irradiated with $^{60}Co$ less than 10%. In bone marrow of mice that received irradiation with subsequent transplantation, less than 10% of the cells had taken up $^3H$-thymidine by the 5th day of transplantation; however, a very rapid increase was noted from the 6th day. It exceeded 30% on the 10th day but started to decrease to about 20% at 2 weeks. Similar results were obtained with in vitro tests. (BBB)

**425** EXPERIMENTAL STUDIES ON THE ANTIGENICITY OF ORGANS AND SERUM OF X-IRRADIATED ANIMALS IN THE HOMOLOGOUS ANIMAL. PART I. STUDIES ON THE HOMOLOGOUS ANTIGENICITY OF EMULSION OF THE LIVER, PRETREATED BY X IRRADIATION IN RABBITS. Sakakura, Takehiko (Mie Prefectural Univ., Japan). Arerugi, 15: 75-83(Feb. 1966). (In Japanese).

In the reported experiments, the possibility was studied of whether organs or serum of animals receiving x irradiation to inhibit protein synthesis develop antigenicity in homologous animals without addition of adjuvant in the inoculant. An emulsion was obtained from the liver of rabbits locally treated by daily irradiation with 500 R for a total dose of 6000 R for 12 days. Other rabbits were sensitized and challenged by repeated intraperitoneal injections of supernatant of this emulsion of irradiated liver. Complement-fixing antibody, antileukocyte antibody, and precipitating antibody were demonstrated in the serum 9 to 18 days after sensitization. Although anaphylactic shock or the Arthus phenomenon failed to develop, decrease in serum albumin content occurred and an increase in $\gamma$-globulin content of serum was observed consistently. Microscopically, the most severe damage was observed in the liver tissue, contrasting to normal histological findings in the control groups treated either by injection of nonirradiated liver emulsion, or by a sensitizing injection not followed by hyperimmunization. It is concluded that the irradiated liver antigen did present consistent antigenicity to homologous animals and the response to the antigen appeared to be similar to the pathological picture of auto-immune disease. (BBB)

**426** GLUTATHIONE CONTENT OF RAT ORGANS AFTER WHOLE-BODY IRRADIATION. Rathgen, G. H. (Univ., Mainz). Arch. Gynaekol., 202: 479-81(1965). (In German).

The results show that 30 min after whole-body irradiation with 800 R variations are detectable in the glutathione content of the liver and spleen. These variations concern both the oxidized and the reduced fraction of the total glutathione. In the spleen the oxidized glutathione is reduced to half its normal value and the reduced glutathione is decreased about 30%. In the liver there is also a reduction of the oxidized fraction and the reduced glutathione is decreased by about 50%. Twenty-four hrs after the whole-body irradiation clear deviations from the normal values are still detectable. The content of reduced glutathione is further reduced in the spleen after 24 hrs, but no reduction is detected in the liver. (J.S.R.)

**427** SPECIES DIFFERENCES IN THE IN VITRO SENSITIVITY OF LYMPHOCYTES TO PREDNISOLONE AND X RAYS. Batra, Karam V.; Elrod, Lloyd M.; Schrek, Robert (Veterans Administration Hospital, Hines, Ill.). J. Pharmacol. Exp. Therap., 152: 525-8(June 1966).

When lymphocyte suspensions derived from the blood of different species were incubated at 37°C with 10 $\mu g$/ml of prednisolone, lymphocytes from man and the guinea pig were found to be relatively resistant to prednisolone, while lymphocytes of mouse, rat, and rabbit were sensitive. The lymphocytes from the blood and spleen had the same sensitivity to the steroid except that human lymphocytes of the spleen were slightly more sensitive than blood lymphocytes. In view of species differences in sensitivity of lymphocytes to prednisolone, x rays (100 R) were used to compare sensitivity of lymphocytes of different species. Human blood lymphocytes proved to be the most radiosensitive (96.8% effect after 7 days of incubation) and guinea pig lymphocytes the least (62.9% after 2 days of incubation). The differences in sensitivity of lymphocytes to x rays were not as large as with prednisolone and no significant correlation was observed between the sensitivity to x rays and to prednisolone. Statistical analysis showed that blood lymphocytes of men were significantly more sensitive to 100 R than were those of the rat, rabbit, and guinea pig. No significant differences were seen between splenic and blood lymphocytes of the lower animals but human splenic cells were slightly less radiosensitive than blood lymphocytes. Other in vitro findings showed that irradiation with 1000 R to human lymphocytes produced 50% effect after 1 day of incubation, 83% after 2 days, 94% after 3 days and 98% after 7 days. Therefore, to compare the reactions of lymphocytes of different species, it seemed best to choose for each species the period of incubation that provided 30 to 60% survival of the untreated lymphocytes. These findings on sensitivity to prednisolone compare well with the classification of species into two categories, cortisone-resistant and cortisone-sensitive. This classification is based on reports of in vivo reactions such as the effects of cortisone on body weight, $\gamma$-globulin synthesis, and antibody production. In vitro sensitivity of lymphocytes to prednisolone correlates with a variety of in vivo measures of sensitivity to cortisone. Various hypotheses are considered to explain the species differences in the sensitivity of lymphocytes to prednisolone. (BBB)

**428** EFFECT OF X-IRRADIATION ON THE DEVELOPMENT OF POSTINFECTION IMMUNITY IN TULAREMIA AND ANTHRAX. Vancurik, J. (Military Inst. of Hygiene, Epidemiology, and Microbiology, Prague). Folia Microbiol. (Prague), 11: 131-8(1966).

Live vaccine of tularemia and anthrax was administered to x-irradiated rabbits, guinea pigs, and rats. Postinfection immunity in anthrax was evaluated by active challenge and in tularemia by challenge and ability of immunized animals to clear virulent microorganisms from blood in active protection tests and by comparison with antibody response. Guinea pigs were x irradiated with 187 or 217 R. Two or 3 days later they were injected with $10^7$ or $10^4$ cells of tularemia vaccine and 30 days after vaccination they were infected with highly virulent bacteria. The process of immunogenesis was highly radioresistant, although the guinea pigs were vaccinated in the phase of antibody formation which is radiosensitive. The guinea pigs were reliably protected against doses 10,000 times the MLD value. The number of deaths in the group of irradiated and nonirradiated animals showed no difference. Only with large challenge doses of $10^7$ bacteria was the number of deaths in the group of irradiated guinea pigs higher than in the nonirradiated group. Formation of agglutinating antibodies did not show any difference between irradiated and nonirradiated immunized animals varying only in the rate of increase of agglutinating titers. Rats irradiated with 420 R were 3 days later injected subcutaneously with $10^6$ and $10^7$ cells of tula-

remia vaccine, and the surviving rats were infected with $10^8$ and $10^9$ cells of a virulent strain. An increased number of deaths and a marked depression of antibody formation was found in irradiated rats. At intervals after irradiation with 400 R rabbits were injected with anthrax spores. The surviving animals at 1–2 months after irradiation were infected with 20,000 and 100,000 spores. No difference was found either in the number of surviving irradiated and non-irradiated immunized rabbits or in the degree of acquired resistance. In all experiments, postinfection immunity proved to be radioresistant; in rats and partially also in guinea pigs infected with tularemia a pronounced difference was found between the effect of radiation on anti-body formation and on postinfection immunity. (TSS)

**429** STUDY OF PRIMARY HEMOSTASIS IN THE RAT AFTER WHOLE-BODY IRRADIATION. Sinakos, Z.; Caen, J.; Dupertuis, D.; Bourdon, R.; Bernard, Jean (Hopital Saint-Louis, Paris). Nouv. Rev. Franc. Hematol., 5: 783-7(Sept.-Oct. 1965). (In French).

Effect on platelet function (agregability in vitro and adhesion in vivo) of 600-rad whole-body x irradiation of rats was studied. The platelet count was not altered one day postirradiation but was decreased 35% on the fifth day and 90% on the eighth day. A hemorrhagic syndrome was evident by the fifth day. Aggregation of platelets after addition of ADP was augmented postirradiation. Phase microscopy showed no change in platelet morphology after irradiation. It is concluded that the hemorrhagic diathesis seen after irradiation is the result of progressive thrombocytopenia. Bleeding time is prolonged without modification of the in vivo adhesiveness of platelets. Paradoxically, in vitro agregability of platelets in the presence of ADP is increased, but this appears to result from changes in plasma rather than platelets. Slow degradation of ADP probably occurs in plasma of irradiated animals. No change in the behavior of platelets in vitro could be noted other than the ADP-induced hyperagregability. (BBB)

**430** THE SKIN OF PRIMATES. XIX. THE RELATIONSHIP BETWEEN MELANOCYTES AND ALKALINE PHOSPHATASE-POSITIVE CELLS IN THE POTTO (PERODICTICUS POTTE). Kechijian, Paul (Albany Medical Coll.). Anat. Rec., 152: 317-23(July 1965).

The effect of uv radiation on melanogenesis was studied with emphasis on the relation between alkaline phosphatase-positive (APP) cells and the melanocyte system in the epidermis of the potto. Clipped skin area was exposed to $62 \times 10^4$ erg/cm$^2$ uv irradiation from a sun lamp six days a week for a total of 30 treatments. Nonirradiated epidermis contained 450 APP cells/mm$^2$; this value decreased to 273 cells/mm$^2$ by the end of the fifth exposure, then gradually returned to normal. The density of these cells remained constant throughout the rest of the experiment. Nonirradiated skin contained few recognizable melanocytes. After repeated stimulation, DOPA-reactive melanocytes showed a general increase in number to a value comparable to that for APP cells. Repeated exposures caused an increase in the dia of both DOPA-positive and APP cells and the thickness of the epidermis gradually increased. The results suggest that in the hairy skin of the potto, APP cells and melanocytes (both melanotic and amelanotic) are the same cell. The number of melanocytes (APP cells) remains constant, and irradiation stimulates melanogenesis in these cells. Further evidence that APP cells and melanocytes are the same cell lies in the fact that both types occupy identical loci. It is concluded that uv irradiation profoundly alters melanogenesis while leaving the alkaline phosphatase enzyme system relatively unaffected. (TCO)

**431** EXPERIMENTAL STUDY ON NEUTRON-INDUCED CATARACT. III. HISTOLOGICAL CHANGES IN CRYSTALLINE LENS OF RABBITS FOLLOWING FAST-NEUTRON IRRADIATION. Choshi, Kanji (Hiroshima Univ.). Nippon Ganka Gakkai Zasshi, 68: 1832-40(Nov. 1964). (In Japanese).

Adult rabbits were irradiated with fast neutrons (14.1 MeV) from a T(d,n)He reaction neutron generator. Development of opacities of the lens was observed clinically, and the lens was subjected to histological examination. In the low-dose exposure groups ($5 \times 10^8$ to $2 \times 10^9$ n/cm$^2$), the histological changes consisted of migration of pseudo-epithelial cells towards the posterior pole beneath the posterior capsule and movement of the undifferentiated fibers into the posterior cortex. In the medium-dose groups ($4 \times 10^9$ to $1.6 \times 10^{10}$ n/cm$^2$), a slight displacement of the nuclear arc was noted in addition to the above changes. Among those exposed to doses in excess of $8 \times 10^9$ n/cm$^2$, slight regressive degeneration of the anterior subcapsular epithelium near the equatorial region and slight swelling of the posterior cortex lens fibers were noted. In the high-dose groups ($3.2 \times 10^{10}$ to $9.6 \times 10^{10}$ n/cm$^2$), the changes were similar to those observed in the above two groups but were more severe. Furthermore, swelling and disintegration of posterior cortex lens fibers and vesicle cells of the posterior subcapsular region were noted, and in some cases swelling of the anterior cortex was also observed. These changes are similar to the histological findings reported for experimental radiation cataracts induced by x rays, and no changes peculiar to fast-neutron effects were observed. (BBB)

**432** A CONTRIBUTION TO THE QUESTION: HOW LONG IS THE EFFECT OF AN X IRRADIATION STILL PERCEPTIBLE? Maggiore, A. (Univ., Geneva). Dermatologica, 131(5): 418-20(1965). (In German).

Guinea pigs were irradiated with 800 R of 50-kv x ray following local application of estrogen to the nipples. The incidence of mitoses produced was visualized by injection of colchicine, which blocks mitoses in metaphase. No histological changes were observed. There were a reduced number of mitoses detectable 26 days after the irradiation, and the number of mitoses was normal after 46 days. In a second experiment, 40 days after a single nipple of the guinea pigs had been irradiated with 800 R both nipples were irradiated with 800 R. Estrogen was applied as before 5 days after the second irradiation, and the mitoses were then made visible by colchicine. The nipples irradiated twice showed fewer mitoses than those that had been irradiated but once. The results indicated that 40 days after irradiation its effects were still detectable. (BBB)

**433** EFFECTS OF X-IRRADIATION OF A PART OF THE BODY ON THE OVARY IN THE LOACH, MISGURNUS ANGUILLICAUDATUS. Egami, Nobuo; Aoki, Kazuko (National Inst. of Radiological Sciences, Chiba). Annot. Zoolog. Jap., 39: 7-15(Mar. 1966).

Forty-seven groups of female fish of the loach, Misgurnus, were irradiated with 0, ¼, ½, 1, 2 or 16 kR of x rays. In some of these groups, fish were subjected to whole-body irradiation, while in the others, only a part of the body was irradiated, the rest of the body being shielded from radiation. At various intervals after irradiation, the anterior and posterior parts of the ovaries of these fish were studied histologically. Following irradiation with doses of 1 kR or smaller, no marked changes took place in the ovaries within 2 months. If the whole-body or the anterior part of the body was irradiated with 2 kR, some large oocytes containing yolk vesicles and yolk granules underwent degeneration, whether the oocytes had been exposed to radiation or not. However, small oocytes were not affected in any part of the ovaries. Responses of the ovaries to irradiation with 16 kR were quite different from those to 2 kR. Oocytes at all developmental stages were completely damaged only in the region of the ovaries directly irradiated, the irradiated portion of the ovaries being sharply defined histologically from non-irradiated portions. These findings seem to be in harmony with the conclusion drawn from the experiments on Oryzias that destructive effects of 2 kR of x rays on the ovary are largely due to a reduction of gonadotropin secretion from the pituitary gland affected by irradiation, while those of 16 kR can be ascribed to damage directly inflicted on oocytes. (auth)

**434** EFFECT OF LARGE DOSES OF IONIZING RADIATION ON THE HEALING PROCESS OF HEPATIC WOUNDS (EXPERIMENTAL STUDY). Ogii, P. E. (Ter-

nopol Medical Inst., USSR). Klin. Khir., 44: 28-32(June 1965). (In Russian).

Sixty-three rabbits, 2.5–3 kilograms in weight, were used in experiments conducted to determine the effect of large doses of ionizing radiation on the healing process of hepatic wounds. The animals were exposed to radiation in doses of 1090 R and placed in wooden boxes. Wounds 4–5 centimeters long and up to one centimeter deep were inflicted on the right lobe of the liver. Ten of the rabbits were subjected to surgical interference only and were used as controls. Periodic examinations of the blood for leukocyte content were made, and cardiograms were recorded in the course of the experiments. The rabbits of the control group and the irradiated animals which survived the operation were sacrificed at various periods of up to 10 days, 3, 4, 6, and 8 weeks, and 3 months after the experiments were initiated. Sections of the liver taken from the area of the lesion were histologically examined. The data obtained established that large doses of ionizing radiation to a considerable degree retard the healing process of the hepatic wounds, the degree of retardation depending on the phase of the radiation sickness and the period in which the wounds were inflicted on the animals. In the experimental animals the growth of granulation tissue was accelerated, such acceleration depending on the rate of the alleviation of the radiation sickness symptoms. The growth process of the tissues, however, was considerably slower in the experimental animals than in the control rabbits. (auth)

**435** HISTOLOGICAL CHANGES OF ENDOCRINE GLANDS IN PREGNANT MICE FROM DRINKING RADIOACTIVE RAINWATER. Muto, Tatsukichi (Mie Prefectural Univ. School of Medicine, Tsu, Japan). Mie Kaibo Gyosekishu, 14: No. 6, 9-17(1963). (In Japanese).

A study was made in pregnant mice of the histological changes in endocrine glands caused by drinking 0.42 to 1.59 $\mu\mu$C of radioactive rainwater. Neither malformed nor dead embryos were seen but the mothers showed histological changes in some endocrine glands. In the anterior lobe of the hypophysis, pyknosis in the chief and basophilic cells was found even in animals drinking of 0.42 $\mu\mu$C of radioactive rainwater. As the radioactivity became stronger, the changes became more pronounced. In the pineal body, mild pyknosis was detected when 0.58 $\mu\mu$C was used, and small vacuoles appeared in the 1.59 $\mu\mu$C group in the degenerating cytoplasm of parenchymal cells. The thyroid gland did not always show changes which paralleled the level of radioactivity, but in some cases it caused marked hyperemia (0.87 $\mu\mu$C), dark red colloid when stained with azocarmine, and atrophy of cells (1.34 $\mu\mu$C). In the thymus, large acidophilic cells with small, dense nuclei were found, even in the 0.42 $\mu\mu$C group and became more frequent in the higher radioactivity groups. In the adrenal gland, hyperemia and atrophy of zona fasciculata were found. In the pancreas, changes, such as pyknosis of nuclei and atrophy of cytoplasm of islet cells, were induced even in low radioactivity groups. It is concluded that drinking radioactive rainwater disturbs, even at low radioactivity levels, the function of endocrine systems. (BBB)

## Radiation Effects on Plants

**436** ACTION OF A HIGH DOSE OF THERMAL NEUTRONS ON THE MORPHOLOGICAL STRUCTURE OF VEGETABLE CELLS. Tselishchev, S. P. Izvest. Timiryazen Sel'kokhoz. Akad., No. 3, 152-62(1964). (In Russian).

The irradiation of dry pea seeds with thermal neutrons at values of the integral dose not exceeding $1 \times 10^{13}$ neutrons/cm$^2$ does not lead to those disturbances of the normal cellular division which are caused by fast neutron irradiation and are not found in the irradiation of seeds and products with $\gamma$ rays and x radiation. The irradiation of pea seeds with integral thermal neutron doses at values not exceeding $1 \times 10^{13}$ neutrons/cm$^2$ produced profound modifications of all physiological processes, premature pathological aging of meristematic cells, and complete destruction of the tissue. In some dose intervals, possibly very narrow and depending on the biological characteristics of the irradiated plant, the neutron-induced changes of nuclear metabolism lead to creation within the meristematic cells of specific conditions favoring the appearance of unusual non-mytotic divisions of cell nuclei by means of the formation of new daughter cells in the original mother nucleus. The appearance of such nonmytotic divisions in plants during irradiation of seeds with x or $\gamma$ radiation is not mentioned in the literature. This leads to the hypothesis that the capacity of inducing massive formation of nonmytotic nuclear divisions is a characteristic of neutron radiation caused by a high concentration of ionization energy and with excitation in particle tracts generated in the volume of the irradiated tissues. (tr-auth)

**437** EFFECT OF IONIZING RADIATION ON PLANTS. Serebrenikov, V. S. (Scientific Research Inst. of Potato Growing, USSR). Biol. Shkole, No. 2, 74-9(Mar.-Apr. 1965). (In Russian).

The radiation of seeds of beans, peas, wheat, and flax with the same x ray doses produces quite diverse effects. At low doses — 150–300 R — plants of beans and peas grown from irradiated seed grow and develop considerably better than from nonirradiated seeds, while for wheat and flax plants no differences in growth and development compared to the control are found. Increased irradiation doses to 1,000–2,000 R have a positive effect on the growth of wheat and flax, while the seeds of beans and peas at these doses lose germination, although individual seeds do grow, but the shoots rapidly wither away. Radiosensitivity of plants differs not only with respect to species and varieties, but also for plants of the same variety, depending on the physiological condition at the moment of irradiation. In experiments on potatoes, eyes taken from nonirradiated tubers were transplanted to irradiated tubers, and vice versa. When eyes were transplanted from nonirradiated tubers to tubers irradiated with 1,000 R, the transplanted eyes grew and developed well, while the same eyes planted on tubers irradiated with doses of 10,000–50,000 R developed weakly, and then growth halted altogether. It is assumed that the effect of stimulation or inhibition of tuber growth is associated with the effect of substances forming due to irradiation, which have a positive effect at low irradiation doses and a negative–at high. In recent years, many studies have been carried out on the action ionizing radiation has on the synthesis of nucleic acids and plant cells (in fact, in most studies a plant-growth inhibiting effect of irradiation doses has been found). The content of nucleic acid is considerably reduced in irradiation, for example, of shoots of barley — with a dose of 2,000 R, and sprouts of rye — with a dose of 5,000 R. In experiments on potatoes, nucleic acid synthesis was inhibited upon irradiation with a dose of 1,000 R, and DNA content was especially severely reduced, and in this case the intensity of cell division was very low; for a dose of 300 R, the amount of nucleic acids was increased by 25–30%, and the intensity of cell division was increased at the same time. Some experiments have shown that in contrast to high doses, the prolonged action of low doses of gamma-rays has a positive effect on growth and development of plants. (TCO)

**438** IMPORTANCE OF THE USE OF RADIOACTIVE SUBSTANCES AND IONIZING RADIATIONS IN PHYTOPATHOLOGY. Nagler, M. Natura, Ser. Biol., 16: No. 6, 17-25(Nov.-Dec. 1964). (In Rumanian).

A review is presented of the principal results of phytopathological studies obtained with the aid of radioactive substances and ionizing radiations, analysis of the effects of ionizing radiations on phytopathogenic microorganisms, the possibility of using them to fight plant diseases, and the importance of radioactive tracers in phytopathological studies. (25 references.) (JPRS)

**439** RADIATION EFFECTS ON BANANA CORMS, MUSA SAPIENTUM. Azzam, H.; Linden, D. B. (Puerto Rico Nuclear Center, Mayaguez). J. Agr. Univ. Puerto Rico, 49: 270-1(Apr. 1965).

Attempts were made to develop a disease-resistant mutant banana by $^{60}Co$ $\gamma$ irradiation of the Gross-Michel variety. Preliminary trials were conducted to establish optimal doses for mutagenesis. Five corms were irradiated with doses ranging from 2,500 to 40,000 R, but there was no germination with dosages above 5,000 R. In the treatment with 5,000 R two plants were produced 1 week apart. The 2,500 R treatment resulted in five plants, two of which appeared normal, and the other three showed symptoms similar to those shown by plants affected with banana mosaic virus. As the possibility of mosaic infestation was excluded, these symptoms must have resulted from the effects of radiation, possibly as a result of temporary hormonal imbalance, because 2 months later these three plants recovered. Plants in the 2,500-R and 5,000-R groups were smaller than control plants at 5 months. Differences in plant heights probably represent differences in the rate of plant growth. It appeared that a mutagenic dose for banana corms is between 2,500 and 5,000 R, probably closer to 5,000. Future treatments with a larger number of corms will be made to determine the exact dose, after which several hundred corms will be treated for field observations and selection of disease-resistant mutants. (TCO)

## Radiation Effects on Microorganisms

**440** CHARACTERIZATION OF AN UNUSUAL DEFECTIVE LYSOGENIC STRAIN OF ESCHERICHIA COLI K12 (λ). Fuerst, C. R.; Siminovitch, L. (Univ. of Toronto). Virology, 27: 449-51(Nov. 1965).

A defective lysogenic strain of E. coli K12(λ), designated T70, was isolated which shows unusual sensitivity to uv radiation. It was recovered upon assay for viable cells of a culture of the lysogenic strain Y10 that had been subjected to thymine starvation in the presence of 5-bromouracil. Isolate T70 resembles other defective strains in failing to produce a normal yield of infective λ particles following uv irradiation, but is unique in a number of other respects. Besides being usually sensitive to killing by uv light, it differs from most other defective isolates of K12(λ) in that induction of phage development seems to occur in only a small fraction of the irradiated cells. Cultures of T70 neither lyse nor produce any infective phage particles following exposure to doses of uv light ranging up to those ordinarily used for induction of λ development in normal strains of K12(λ). That failure of uv-irradiated cultures of T70 to lyse or produce any infective phage must be attributed, at least in part, to failure induction, is shown by the fact that less than 0.1% of the cells lose their immunity to infecting λ particles after uv irradiation. The unusual character of T70 could be attributed either to a mutation in the host, or in the λ prophage, or both. This was shown by tests of the phage-producing ability of T70 lysogenized with healthy phage particles. Results indicated that the original strain T70 carries at least two genetic defects, one involving the λ prophage and a mutation of the host that is responsible for high sensitivity to killing by uv and noninducibility of carried prophage. This conclusion was supported by studies of the nonlysogenic segregant T70-1, which is as sensitive to killing by uv irradiation as T70. Genetic recombination and repair of uv lesions might require expression of a common gene function. (BBB)

**441** EFFECT OF GAMMA-RAYS ON SOME GROUPS OF SOIL MICROFLORA. Bernard, V. V. Agrobiologiya, 4: 610-16(1962). (In Russian).

The effects of varying doses of gamma radiation on soil microflora were studied under laboratory conditions. Damaging effects were observed at doses above 15,000 R. Doses of 100,000 R were lethal for azotobacteria (strain 53) and nitrobacteria irradiated in sand and soil. The nitrogen- and nitrate-fixing capacity of cells remaining alive after irradiation was not altered. The effect of gamma rays was evident in a radius of only 20 to 50 cm from the source. Fermentation activity of surviving cells was not affected. Radiation effects depended on length of exposure. A dose of 376,000 R was not lethal over a period of 7 days in the gamma field. The cells were almost completely inactivated in the laboratory at a dose of 100,000 R with an exposure time of 3 hrs and 20 min. Multiplication of cells occurred during irradiation at a dose of 40,000 R for 14 days in the gamma field. Following the period of irradiation the cells were viable and multiplied actively. (H.L.W.)

**442** VARIATION IN YEAST CELL SENSITIVITY TO ULTRAVIOLET RAYS, AS DEPENDENT ON THE PHASE OF GROWTH AND AERATION CONDITIONS. Samoilova, K. A.; Mityushova, N. M.; Malinovskii, O. V. (Inst. of Cytology, Academy of Sciences, USSR. Pavlov Inst. of Physiology, Academy of Sciences, USSR). Dokl. Akad. Nauk SSSR, 166: 1230-2(Feb. 11, 1966). (In Russian).

Saccharomyces vini cells in the exponential growth phase were found to be considerably more resistant to ultraviolet (2537 A) irradiation at all doses in the range studied (800 to 6400 ergs per square millimeter at a rate of 1600 ergs/mm$^2$/min) than they were in the stationary phase. For those in the growth phase resistance was slightly higher under aerobic conditions than under anaerobic, but for those in the stationary phase the reverse was true. The greater viability of the former is thought to be due to a higher resistance of the cells rather than to a larger number of budding cells, and the resistance to radiation in the growth phase of single cell organisms may be due principally to the higher rate of formation of high-molecular-weight RNA synthesis. In the experiments described the viability of the yeast was determined by the macrocolony method. (TTT)

**443** POSSIBILITY OF USING PHOTOREACTIVATION AS A MODEL OF POSTRADIATION RESTORATION. Kabakov, E. N. Zh. Obshch. Biol., 26: 368-72(1965). (In Russian).

The dependence of microorganisms upon their ploidy in the case of sensitivity to x and uv irradiation, as well as the nature of cell destruction caused by these agents is discussed. Photoreactivation illustrates the fact that restoration proceeding in the cell after uv irradiation is characterized by peculiarities specific for this effect only. They include the fact of photoreactivation itself, its dependence upon the endo- and exogenous nutrient substrate, possibility to practically eliminate the lethal effect of irradiation by a combined use of photo reactivation and dark reactivation, etc. It was concluded that it is impossible to use photoreactivation as a model of cell restoration after ionizing irradiation. (auth)

## Radiosterilization and Radiopreservation

*Refer also to abstract 208.*

**444** (TID-23370) [PROGRESS REPORT ON EFFECTS OF HEAT AND GAMMA IRRADIATION ON ASCORBIC ACID CONTENT OF NECTARINES AND PEACHES, SEPTEMBER 1966]. Letter Report. Maxie, E. C. (California Univ., Davis. Dept. of Pomology). Sept. 7, 1966. Contract AT(11-1)-34. 4p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Combinations of hot water dips at a temperature of 50 to 52°C for 3½ min with doses of 100 kR of radiation continue to show promise for the control of brown rot in peaches and nectarines. Tests were made to ascertain the effect on ascorbic acid content, texture, and organoleptic attributes of fruits treated with heat and radiation. (F.S.)

**445** DIRECT GAS CHROMATOGRAPHIC ANALYSIS OF VOLATILES PRODUCED BY RIPENING PEARS. Romani, R. J.; Ku, Lily (Lim) (Univ. of California, Davis). J. Food Sci., 31: 558-60(1966).

A direct non-destructive sampling and gas-chromatographic analysis technique are described for analyzing the

volatiles from ripening pears as a measure of the aging of the pears. The volatiles emanating from ripening pears previously irradiated with gamma radiation to retard aging are tentatively identified. The chromatographic traces demonstrate the inhibition of the ripening of the fruit by ionizing radiation. (B.L.M.)

**446** PRESENT STATUS OF FOOD IRRADIATION. Goresline, H. E. (International Atomic Energy Agency, Vienna). Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-75/29, 10p. (CONF-660711-6). ORAU.

From Seminar on the Use of Radioisotopes and Radiation in Dairy Science and Technology, Vienna.

The status of the food irradiation program is reviewed, including radurization, radicidation, and radapperization. Results of radurization treatments of fruit, vegetables, fish, and meat and poultry are reviewed. Radicidation in meat and poultry, fish and seafood, eggs, and miscellaneous items is summarized. Radappertization has been the most popular of the processes because of the potential for producing foods that more closely resemble items as prepared for table than do most heat-processed products. It is pointed out that the safe treatment for food of pH 4.5 and above must be designed specifically to kill Clostridium botulinum spores. So far, irradiation of non-acid vegetables has not been satisfactory due to the softening of texture caused by the combined heat and irradiation treatment, and no class of dairy foods can be successfully irradiated. However, radiopreservation of a number of stable fish items has been reported. (H.G.D.)

# METALS, CERAMICS, AND OTHER MATERIALS

## Metals and Alloys

**447** (BMI–1778) PROGRESS RELATING TO CIVILIAN APPLICATIONS DURING JUNE 1966. Keller, Donald L. (Battelle Memorial Inst., Columbus, Ohio). July 1, 1966. Contract W-7405-eng-92. 23p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Research results are presented on radiation effects on 347 stainless steel, behavior of interstitial elements on Cr–Y alloys, explosive welding of Zircaloy–Al tubing, thermal stability of Sol-Gel, $ThO_2$–$PuO_2$ particles in various atmospheres, development of fuel plates for AARR, room-temperature stability of UN–PuN in $O_2$ and vacuum, thermal conductivity of irradiated UN, compatibility UN–PuN fuels with 300-series stainless steels, radiation damage in UN–PuN fuels, smoke photometer development, and corrosion of fluoride-volatility process construction materials. (J.R.D.)

**448** (CONF-650411) AEC-NASA LIQUID METALS INFORMATION MEETING HELD IN GATLINBURG, TENNESSEE, APRIL 21–23, 1965. (Oak Ridge National Lab., Tenn.). Contract W-7405-eng-26. 399p. Dep. mn. CFSTI $7.00 cy, $1.75 mn.

A total of 34 papers is presented which cover the following topics: analysis, solubility studies, impurity effects, and corrosion by liquid and boiling alkali metals. Eight of the papers have appeared previously in NSA; see NSA, Vol. 19, abstracts 22890, 22981, 22982, 26282, 34640, 39157, and 44211; see also NSA, Vol. 20, abstract 21284. (D.L.C.)

**449** (SCL-DC-66-22) THICK NICKEL DEPOSITS OF HIGH PURITY BY ELECTROLESS METHODS. Dini, J. W.; Coronado, P. R. (Sandia Corp., Livermore, Calif.). June 1966. Contract AT(29-1)-789. 24p. (CONF-661202-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Symposium on Plating in the Electronics Industry, American Electroplaters' Society, Newark, N. J.

A method is presented for producing thick, relatively pure Ni deposits by autocatalytic reduction in solutions containing nickel acetate, glycolic acid, a sodium salt of EDTA, and hydrazine. Stability and plating rate were found to be good provided the composition of the solution was kept within certain fixed limits and salts of high purity were used. Experiments showing the optimum formulation and optimum operating conditions are described. Deposits up to ten mils thick with 99% purity were produced. Metallographic examination and x-ray diffraction revealed their structure to be extremely fine grained. Deposits were highly stressed. Hardness in the as-deposited condition was 360 to 500 Knoop; ductility was poor. Heat treatment at 760°C improved ductility markedly and lowered hardness to 85 Knoop. Density also was lowered. Corrosion resistance was inferior to that of deposits produced in electroless hypophosphite baths and electrolytic sulfamate baths. Possible applications of the process are suggested. (auth)

### Corrosion and Erosion

*Refer also to abstracts 465, 478, 501, 529, and 1155.*

**450** (AECL–2537) PRODUCING THICK OXIDE LAYERS ON Zr–Ti ALLOYS FOR ENHANCED WEAR RESISTANCE IN WATER-LUBRICATED MECHANISMS. Watson, R. D. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). June 1966. 23p. Dep. mn. AECL $1.00.

Five Zr-Ti binary alloys having compositions in the range Zr–0.5 wt % Ti to Zr–10 wt % Ti were investigated for oxide-film-forming characteristics in air at 300 to 800°C. Under certain conditions a reasonably thick uniform and tightly adherent oxide layer can be formed on all five materials. Black oxide layers up to 0.0035 in. thick can be produced at 700 to 800°C; white or off-white layers up to 0.008 in. thick can be formed at 350 to 400°C. The Ti content of the alloys has a pronounced effect on the color, thickness and quality of the oxide layer. About 22 different oxide coatings were wear tested in water at room temperature. A number of the coatings had excellent wear resistance but the coatings produced by heating Zr–10 wt % Ti and Zr–5 wt % Ti in air at 400°C for 65 h were best. A number of oxidized specimens were corrosion tested in water at 260, 177 and 77°C. At 77°C the corrosion resistance was generally very good; at 260°C the corrosion resistance was unsatisfactory. (auth)

**451** (AECL–2542) FORMING UNIFORM THICK OXIDE LAYERS ON ZIRCALOY-2 FOR FRICTION AND WEAR APPLICATIONS IN HIGH TEMPERATURE WATER. Watson, R. D. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Mar. 1966. 33p. Dep. mn. AECL $1.00.

Several methods of producing uniform buff oxide layers on Zircaloy-2 were developed. The oxidized material has excellent wear resistance and should be useful for parts in rubbing contact in water-lubricated mechanisms operating at 500°F. The oxidation rate of Zircaloy-2 in air is dependent on the surface texture and the treatment given it. A rough surface produced by machining or grit blasting assures formation of uniform buff post-transition oxide layers. Fine surfaces produced by grit blasting, polishing, machining or grinding decrease the oxidation rate and prevent formation of uniform buff post-transition oxides. Deep scratches increase the oxidation rate apparently because of the surface roughness produced. The oxidation resistance of machined, ground, or polished Zircaloy-2 is not improved by pickling. (auth)

**452** (BAW–1280-37) MATERIALS EXAMINATION OF A MODEL SODIUM HEATED STEAM GENERATOR. Final Report. Research Report No. 5136. Koch, D. W.; Kovach, P. J. (Babcock and Wilcox Co., Alliance, Ohio. Research Center). June 30, 1966. Contract AT(11-1)-1280. 75p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

A test program was conducted to assess the compatibility of Croloy 2¼ and type 316 stainless steel in a liquid Na system. A single tube steam generator was designed to model 1000-Mw(e) steam generator design parameters, and samples were removed from the pipe after 1000 to 8000 hr operation at 600 to 1000°F (Croloy 2¼) and 800 to 1100°F (type 316 stainless steel). During exposure, the Croloy 2¼ surface partially decarburized to depths of 20–25 mils and was enriched in Ni, Cr, and O. The mass transfer from the type 316 stainless steel, confined within 8 microns of the surface, consisted of depletions of Ni and Cr and an enrichment in Fe. The stainless steel also carburized at the Na surface but was sensitized throughout. The mechanical property studies were inconclusive owing to the tempering effects of the exposure. The waterside corrosion behavior in the model was similar to that in conventional steam generators. It is concluded that Croloy 2¼ and type 316 stainless steel as construction materials are satisfactory. (D.L.C.)

**453** (CONF-611003–2) CARBURIZATION BARRIER COATINGS ON GRAPHITE. Del Grosso, A. (Aerojet-General Nucleonics, San Ramon, Calif.). [1961]. Contract AT(10-1)-880. 13p. (AN-ENGR–40). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From American Ceramic Society, Pacific Coast Regional Meeting, San Francisco, Calif.

The development of a high temperature gas-cooled reactor concept utilizing Hastelloy X as a cladding for fueled graphite presented a problem in carburization of the cladding. Preliminary tests of compatibility of Hastelloy X and

graphite samples coated with Mo, NbC, and ZrC were evaluated. Results of chemical and metallographic tests indicated that the Mo and NbC coatings were satisfactory carburization barriers to Hastelloy X at 1750°F and 3000 hours. (auth)

**454** (EIMAC-TR-66-15) INVESTIGATION OF SOLUBILITY AND DIFFUSION OF OXYGEN IN REFRACTORY METALS. Second Quarterly Report, October 1, 1965–December 31, 1965. Pape, R.; Reed, L. (EIMAC, San Carlos, Calif.). Jan. 1966. Contract NAS3-7626. 38p. (NASA-CR-54648).

Electrical resistivity measurements are to be used to determine the solubility limits and diffusion constants of $O_2$ in Ta, Ta–10W, alloy T-222, Nb, Nb–1Zr, and alloy FS-85. An $O_2$ solubility apparatus is operational. Three trial solubility experiments were conducted with Nb specimens and five with Ta specimens. (auth)

**455** (EURAEC-1549) QUARTERLY REPORT NO. 12, [ON CORROSION OF STAINLESS STEELS], OCTOBER 1–DECEMBER 31, 1965. Chaudron, G. (Commissariat a l'Energie Atomique, Paris (France)). Contract 059-65-7TEEF(RD). 49p. (EUR-2691). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

Design of electrochemical equipment for investigation of metal corrosion under tension is discussed. Investigation results are presented which indicate that the tempering temperature producing the optimum mechanical properties in 18-8 stainless steels rises with increase in steel purity. The tempering process gives rise to fast refining of the martensite and formation of austenite. It was also found that tempered steels have less tendency toward passivation than nontempered types. (J.R.D.)

**456** (EURAEC-1675) INVESTIGATION INTO SOME PROBLEMS OF METAL OXIDATION. Quarterly Report No. 2, April 1–June 30, 1966. (Brussels Univ. (Belgium). Faculte des Sciences). Contract 079-64-10 TEEB (RD). 11p. (EUR-2866). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

In all cases the crystals formed by controlled oxidation of solid Al belong to the compound $\gamma Al_2O_3$. The form of the nuclei varies with the orientation of the metal with which they are in epitaxic relation, despite the existence of an amorphous layer at the start. The aspect of the crystals formed by iodination of Cu is strongly dependent on the temperature of the reaction. The phenomenon always seems to be different on either side of the crystallographic transformation points in CuI. (auth)

**457** (EURAEC-1689) STUDIES OF STEEL CORROSION IN HIGH TEMPERATURE WATER AND STEAM. Quarterly Report No. 15, April 1–June 30, 1966. (Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Brussels (Belgium)). July 25, 1966. Contract 087-66-1 TEEB (RD). 79p. (EUR-2876). Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

A study of the recrystallization conditions of various grades of milled stainless steels is discussed. The effects of heat-treatment time-length were investigated at 675°C. AISI 410, stainless steel is completely recrystallized after 1 hour at this temperature. Periods of up to 24 hr did not produce marked recrystallization in any of the austenitic grades examined. Long-duration tests in superheated steam at 500°C conducted on AISI 304 L steel confirmed previous conclusions. A work-hardening depth of 5 to 6 μm seems sufficient to guarantee good long-term behavior of this steel. Incoloy 800 and Inconel 600 were exposed for 1,000 hours to steam at 500 and 600°C. The weight results indicate that, in the milled state, Incoloy 800 behaves like AISI 304 steel and seems less sensitive to the rise in the temperature of the steam. Inconel 600 is less affected by the initial surface treatment than alloys containing less Ni. The extension of the tests on Zircaloy 2 confirms that the surface treatment has very little effect on the oxidation resistance of this alloy. The scatter in the results concerning the hydridation rate necessitates further determinations. Dynamic corrosion tests were conducted in water at 250 and 300°C, at 150 kg/cm², at a rate of 10 m/sec; the water was deliberately loaded with corrosion products by exposing a large surface area of AISI 410 stainless steel. Samples of AISI 304 stainless steel show increased corrosion in this medium over the level reached in pure water. 1.2 MD 07 boilerplate steel does not seem to be affected by this factor. The magnetic filtration tests which accompanied these experiments show that this system of filtration can be very effective at 300 and 320°C, whereas at 250°C it is inoperative. The colloidal particles of magnetite in suspension in the water coalesce under the effect of the magnetic field; the agglomerates formed in this way can be retained by an ordinary filter system. (J.R.D.)

**458** (EURAEC-1701) IMPERFECTIONS IN METALS. II. CORROSION AND OXIDATION. Quarterly Report No. 14, December 31, 1965–March 31, 1966. (Centre d'Etude de l'Energie Nucleaire, Mol (Belgium)). Contract 054-64-4 TEEB. 14p. (EUR-2889; R-2384). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

The defect structure caused by mechanical working of stainless steel surfaces was investigated by electron microscopy in transmission. A high density of dislocations was observed which is in agreement with the model proposed elsewhere for the enhanced corrosion resistance caused by such treatments. The precipitation at the grain boundaries of chromium carbides in steel type AISI 304 was studied by the same technique. The precipitation treatments were performed either during the observation in the electron microscope or in a furnace. It was found that no defect structure, caused by the precipitation, is visible near the grain boundaries. A similar mechanism as was proposed for the mechanically deformed surfaces cannot account for the zones of improved corrosion resistance along the grain boundaries. (auth)

**459** (GEAP-3726(Vol.1)) SODIUM MASS TRANSFER. II. SCREENING TEST DATA AND ANALYSIS: MASS TRANSFER RESULTS. Lockhart, R. W. (comp. and ed.) (General Electric Co., San Jose, Calif. Advanced Products Operation). Apr. 1962. Contract AT(04-3)-189. 131p. Dep. mn. CFSTI $4.00 cy, $1.00 mn.

Preliminary results from 21 test runs are presented, covering about 40,000 hours of exposure of corrosion samples in flowing Na at temperatures between 700 and 1200°F. Samples of type-316 stainless steel, 2¼Cr and 5Cr alloy steel were exposed in three temperature steps in both the hot leg and cold leg of each loop. After exposure, the samples were removed from the loop, cleaned, weighed and examined for structural or compositional changes. When activated foil samples were used, they were counted with a multichannel pulse height analyzer. The results show that any of the materials tested could be used in Na systems up to 1200°F. The specific physical properties desired would determine the choice of materials. Selective transport of alloying elements have been indicated by the formation of a transformed (ferritic) layer on the surface of the stainless samples exposed above 1000°F and by radio tracer evidence. In the bimetallic type-316 stainless steel–2¼Cr loops, C is transferred from the ferritic to the austenitic material. The weight change data have indicated nearly the same corrosion rate (~1 mil/yr at 1200°F) for each of the materials exposed under similar conditions. The local corrosion rate is dependent on the temperature, geometry, and location of the sample in the test loop. Sufficient material has been transferred (under some test conditions) to foul or partially plug small channels in the cold leg. The program is being continued to provide extended exposures of samples according to a five-run fractional replicate test plan. (auth)

**460** (GEAP-4834) SODIUM MASS TRANSFER. XVIII. EXTENDED STUDIES OF CARBON MOVEMENT IN PUMPED SODIUM TEST LOOPS. Plumlee, D. E.; Lockhart, R. W.; Pohl, L. E.; Lauritzen, T. A. (General Electric Co., San Jose, Calif. Advanced Products Operation). June 1965. Contract AT(04-3)-189. 82p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The result of exposing stainless steel cylinders and tubing to carbon-contaminated-pumped Na is reported. This is a continuation of some preliminary exposures that were made during the previous year. Diffusion of carbon into the cylindrical rods was observed by machining thin layers of metal from the surface and analyzing the chips for carbon. The thin walled tubing samples were analyzed by obtaining gross C content or were used for physical testing. The samples were exposed for different lengths of time at 850, 950, and 1050°F. The results were used to develop a method for calculating the maximum C content at the Na-exposed steel surface. An analysis of the C data from the existing Sodium Mass Transfer Program corrosion samples is discussed in light of this information. (auth)

**461** (GEAP-4838) SODIUM MASS TRANSFER. XXII. METALLURGICAL EXAMINATION OF THE TEST LOOPS. Rowland, M. C.; Plumlee, D. E. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). Oct. 1965. Contract AT(04-3)-189. 520p. Dep. mn. CFSTI $8.20 cy, $2.25 mn.

Six test loops constructed from various material combinations of Type-316 stainless steel, $2\frac{1}{4}$Cr–1 Mo alloy steel, and 5Cr–$\frac{1}{2}$Mo–$\frac{1}{2}$Ti alloy steel were examined after approximately 20,000 hours exposure to flowing Na in the temperature range of 600 to 1300°F. The long-term exposure results obtained from these loop examinations were compared with results obtained on short term corrosion samples previously exposed in the loops. The bulk of the loop dissection and examination reported was done in 1965, but some earlier work is referred to. (D.L.C.)

**462** (NAA-SR-Memo-11970) REVIEW OF SCTI BELLOWS FAILURES. Leppard, J. A. (Atomics International, Canoga Park, Calif.). May 26, 1966. Contract AT-11-1-GEN-8. 15p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Specimens of each of three failed bellows were examined metallurgically; the material (304 SS) was found to be sensitized and corroded. The corrosion was intergranular and resulted in the occurrence of multiple cracks when the bellows were flexed during sodium loop operation. Investigation revealed that a baking operation had been performed at 1300°F to remove volatile materials between the two plies of the bellows. Because intergranular corrosion occurs with aqueous corrodants, it was concluded that this corrosion occurred during the thirty month period between fabrication and installation in the SCTI plant. Each of the twelve original bellows expansion assemblies was manufactured by the same process, but the extent of exposure to corrodants after manufacture was indeterminant. Short of replacement, no action could be taken to assure long service of the remaining original units. The manufacturing process specification was changed to reduce the bakeout temperature from 1300°F to 800°F to prevent sensitization. Additional requirements were made covering shipping, handling, and storage techniques to eliminate corrosion. (auth)

**463** CORROSION OF YTTRIUM. II. YTTRIUM CORROSION IN HYDROFLUORIC ACID. Altovskii, R. M.; Fedotova, A. G.; Korolev, S. I. Zashchita Metal., 2: 436-8(July-Aug. 1966). (In Russian).

Corrosion kinetics and electrochemical properties of Y were studied in 2 and 18% HF solution at 25 and 90°C. During the first tests (250 hr at 25°C and 24 to 50 hr at 90°C) the rate of corrosion decreased with time because of the protective layer formed on the surface. During the passive stable state caused by the anode delay, the rate of corrosion was 0.02 to 0.05 mm/yr. In the vapor phase, corrosion with deep pitting was observed after 25 hr. (R.V.J.)

## *Preparation and Fabrication*

*Refer also to abstracts 241, 458, and 478.*

**464** (BM-RI-6853) VAPOR DEPOSITION OF MOLYBDENUM–TUNGSTEN ALLOYS. Donaldson, J. G.; Kenworthy, H. (Bureau of Mines, Washington, D. C.). 1966. 12p. Bureau of Mines Free.

Binary alloys of Mo and W were prepared by $H_2$ reduction of their vaporized hexafluorides. Near-optimum deposition parameters were determined, and the nature of the deposited alloys was investigated. Dense, homogeneous alloys were codeposited at 650 to 750°C with a reduction efficiency of more than 75%. The alloy composition was uniform when the $H_2$ ratio in the gas feed mixture did not exceed 3 times the stoichiometric requirement. Regulating the proportions of the metal hexafluorides in the gas feed provided a large degree of control over the composition of the deposit. Hardness of the deposits varied directly with the proportion of excess $H_2$ in the gas feed and with the wt % of W in the alloy. Hardness was not affected by deposition temperature 650 to 750°C for specimens of similar composition. Extreme brittleness and unsuitable physical shapes of the alloys prevented tensile strength measurements. (auth)

**465** (EURAEC-1678) [PREPARATION AND PROPERTIES OF STAINLESS STEELS]. Quarterly Report No. 4, April 1–June 30, 1966. Chaudron, G. (Centre National de la Recherche Scientifique, Paris (France)). Contract 059-65-7-TEEF (RD). 21p. (EUR-2868). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

The effects of C concentration on the properties of austenitic stainless steels of 18-10 type were studied. Alloys with 18% Cr, 12% Ni, and various C contents were prepared. The steels involved are respectively a, steel containing 20 ppM C, b, steel with 80 ppM C, and c steel with 600 ppM C. The mechanical properties of these alloys were determined by measuring the Vickers hardness as well as by recording the tensile curves for wires; the presence of C causes an increase of the elastic limit and the ultimate tensile strength of the steels. The effects of C on the corrosion of austenitic stainless steels were investigated. Particular attention was directed toward corrosion by pitting in ferric chloride; intergranular corrosion by dechromization, revealed by $CuSO_4$ reagent; and intergranular corrosion in boiling $HNO_3$ with addition of hexavalent Cr. (J.R.D.)

**466** (IS-T-106) PACK CARBURIZATION OF IRON UNDER VACUUM CONDITIONS. Carter, George Charles (Ames Lab., Iowa State Univ. of Science and Tech.). July 1966. Contract W-7405-eng-82. 94p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Thesis.

Samples of Fe and Fe alloys have been tested for pack carburization under vacuum conditions at 950°C employing various kinds of C. The type of C employed is a critical factor; sugar carbon, graphite, and diamond have produced very good cases while a number of other carbons have given essentially no carburization in a four-hour period. The type of Fe employed is also a major factor in determining the success or failure of low-pressure pack carburization. Low-carbon steel and carbonyl iron readily absorb C from sugar carbon and from graphite. Armco iron, wrought iron, and electrolytic iron show little or no carburization in any carbon pack. Acetylene carbon failed to carburize any of the irons. A number of alloying elements have been shown to have marked effects on the carburization of Fe in a pack under vacuum conditions. Experiments have been performed with precision-machined steel samples and solid block graphite to obtain carburization data on contact and near-contact conditions for the metal and C. Results from these experiments together with considerations from previous observations have demonstrated that low-pressure pack carburization is not dependent on a gas phase but is accomplished only through physical contact between the C and Fe. Carbon saturation values were

found to have a dependence on the kinds of C and Fe employed. (auth)

**467** (K-L-2338) PROCEDURE FOR ELECTROLESS PLATING OF NICKEL ON FIBERGLASS. Petit, G. S.; Wright, C. C. (Oak Ridge Gaseous Diffusion Plant, Tenn.). Oct. 5, 1966. Contract W-7405-eng-26. 10p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A procedure is given for the plating of an adherent, smooth, and uniform film of nickel on fiberglass cemented with an epoxy resin. The procedure involves the application of a flash palladium coating prior to plating. A 0.002-in. plating requires a force of 1100 lb/in$^2$ to strip it off the fiberglass from a 1-in.$^2$ interface. (D.L.C.)

**468** (MAB-226-M) CHARACTERIZATION OF BERYLLIUM. (Materials Advisory Board, National Academy of Sciences-National Research Council, Washington, D. C.). Aug. 1966. 14p. CFSTI $1.00 cy, $0.50 mn.

A report is presented concerning the major process variables corresponding to the principal operations associated with producing a Be mill product, and Be parts. This compilation comprises a check list which should be reviewed at the start of a research or development effort to ensure that variables which might be significant are not being overlooked. The ultimate object of compiling and studying such data is to assure uniformity, and thus introduce reliability into manufactured parts. (auth)

**469** (ORNL-TM-1606) JOINING OF TUNGSTEN. Gilliland, R. G. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 20p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

A cursory investigation was made of the use of various joining methods on W fabricated by several techniques. W produced by powder metallury, arc-casting, thermochemical deposition (TCD), and molten-salt bath plating was used as the base metal. The joining processes were (1) gas W-arc fusion welding (TIG), (2) gas W-arc braze welding, (3) electron-beam welding, (4) thermochemical deposition joining, and (5) high-temperature brazing. Testing of the various welded joints included three-points bending to determine ductile-to-brittle transition temperatures (DBTT). All joints, both welded and brazed, were evaluated metallographically to assess their general integrity and quality. From this study it was found that the welding of W can be successfully accomplished in a number of different ways, and the use of postjoining thermal treatments can often improve the ductility of the joints. Stress relieving of TIG welds in vacuum in powder metallurgy W for 1 hr at 1800°C reduces the DBTT by approximately 100°C. Gas tungsten-arc welds in TCD material show a 200°C improvement in transition temperature after a vacuum stress relief of 1 hr at 1000°C. These welds exhibited the lowest DBTT (235°C). The use of another filler metal to braze-weld W caused an impairment of joint properties, rather than an improvement, when compared with other welding processes. It was found that all types of W could be successfully brazed using alloys from the Ta-V-Nb and Ta-V-Ti ternary systems. (auth)

**470** (RFP-825) ISOSTATICALLY PRESSED MAGNESIA STIRRERS FOR ELECTROREFINING PLUTONIUM METAL. Teter, A. R. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). Oct. 13, 1966. Contract AT(29-1)-1106. 7p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Several isostatic pressing mold designs were evaluated for fabricating MgO stirrers. Thin walled neoprene molds produced the most satisfactory one-piece stirrers. The pressed stirrers that were developed have been reused as many as five times in the electrorefining process. MgO stirrers formed by suspension casting could be used for only one electrorefining run. (auth)

**471** (SC-RR-66-2070) EXPLOSIVE FORMING OF WROUGHT INGOT BERYLLIUM. Final Report. Bayce, A. E.; Daniels, N. H. G. (Stanford Research Inst., Menlo Park, Calif.). June 1966. Contract AT(29-1)-789; Subcontract 16-5158. 24p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

For Sandia Corp., Albuquerque, N. Mex.

Six experiments were performed to obtain preliminary information on the explosive forming of Be 0.15- and 0.50-in. thick wrought ingot plates. Tests generally resulted in cracking, but also showed evidence of bending corresponding to surface strains of the order of 1/2%. One test, resulting in a larger radium bend, did not cause any cracking of the sample plate. It is considered that improvements in the material condition and in the explosive forming techniques used could lead to a much greater degree of success in forming Be by explosive techniques. (auth)

**472** (TID-23364) STUDIES OF THE PREPARATION OF MIXED CARBIDE FUEL UTILIZING COPRECIPITATION. Quarterly Progress Report No. 1, May 23-August 30, 1966. McMurtry, C. H.; Taylor, K. M. (Carborundum Co., Niagara Falls, N. Y. Research and Development Div.). Contract AT(30-1)-3713. 24p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Process variables were studied in the synthesis of UC utilizing coprecipitation of the C and metal from materials in a common solvent, with $UO_2(NO_3)_2$ and sucrose dissolved in water as starting materials. It was found that varying the pH of the solution by adding $HNO_3$ or $NH_3$ greatly affected the C yield from a given quantity of sucrose. Results also indicated that temperature and atmospheric conditions of coprecipitation and subsequent drying of the residue were important factors in obtaining consistent results. Although it was demonstrated that stoichiometric carbide can be made by this method, sufficient control of variables has not yet been established for good reproducibility. (auth)

**473** WELDING OF REFRACTORY-METAL COMPONENTS FOR LIQUID METAL SERVICE. Franco-Ferreira, E. A.; Slaughter, G. M. (Oak Ridge National Lab., Tenn.). Weld. J. (N. Y.), 45: 835-42(Oct. 1966). (ORNL-P-1977).

A program is under way to evaluate the use of refractory metals for high-temperature, liquid-metal service and to obtain engineering data on these materials. Complex welded components such as corrosion loops and pumps are needed to carry out these tests. The procedures for manually gas W-arc welding these items, using vacuum-pumped inert-atmosphere chambers, are described. An automatic field-welding device capable of being evacuated to $10^{-5}$ torr was developed for making the final welds which tie the refractory-metal components into the test systems. Equipment for sealing corrosion capsules with a contained vacuum is discussed. (auth)

**474** TANTALUM REACTION WITH NbRu. Panteleimonov, L. A.; Nesterova, O. P.; Akhmetzyanov, K. G.; Guts, Z. A.; Sokolova, I. G. Vestn. Moskov. Univ., Ser. II, Khim., No. 1, 40-2(Jan.-Feb. 1966). (In Russian).

Ru, Ta, and Nb were fused by induction heating in a vacuum of $5 \times 10^{-6}$ mm Hg std, and samples were also prepared in an arc furnace in an argon atmosphere with the following compositions: 14% Ta-86 mol % NbRu; 55% Ta-45 mol % NbRu; 70% Ta-30 mol % NbRu; 10% Ta-90 mol % NbRu; 15% Ta-85 mol % NbRu; and 50% Ta-50 mol % NbRu. Samples were quenched in water from 1500°C after being held at this temperature for 10 hr. Annealing was carried out in quartz at 800°C for 1000 hr. The Vickers hardness showed a maximum of 15% Ta, and then fell off. The electrical conductivity was a minimum at 10 to 15% Ta, and increased with further Ta additions to the NbRu compound. The minimum in the melting point was observed at 1780°C at about 15% Ta. The NbRu compound was primitive rhombic with a = 4.351, b = 4.226, and c = 3.365 ± 0.005 Å. With 5% Ta the lattice parameters were: a = 4.351, b = 4.253, and c = 3.345 Å. The 7% Ta alloy was tetragonal, and the 6% Ta alloy showed a single-phase microstructure. The 14% Ta alloy had tetragonal lattice parameters of a = 3.127, c = 3.328, and c/a = 1.064. The 15% Ta alloy had a body-centered cubic lattice with a = 3.286. (TTT)

**475** REACTIONS BETWEEN NbRu AND TaRu COMPOUNDS. Panteleimonov, L. A.; Nesterova, O. P. Vestn. Moskov. Univ., Ser. II, Khim., No. 1, 43-5(Jan.-Feb. 1966). (In Russian).

Alloys in the NbRu–TaRu system were formed by induction heating in vacuum, and by heating Ru, Ta, and Nb in an arc furnace in a argon atmosphere. Samples were quenched in water from 1500°C. Other samples were annealed in quartz at 800°C for 900 hr. The microstructure was observed by electrolytic etching in 10% oxalic acid. Cast samples showed a dendritic structure, while the quenched and annealed samples had a polyhedric structure. The following compositions were studied: 1) 20 mol % NbRu–80 mol % TaRu; 2) 60 mol % NbRu–40 mol % TaRu; 3) 80 mol % NbRu–20 mol % TaRu; 4) 30 mol % NbRu–70 mol % TaRu; 5) 50 mol % NbRu–50 mol % TaRu and 6) 70 mol % NbRu–30 mol % TaRu. The Vickers hardness was a maximum at 50 mol % TaRu. The melting temperature varied from 1900°C for the NbRu compound to 2050°C for the TaRu compound. NbRu and TaRu formed a continuous series of solid solutions over the entire interval of concentrations. (TTT)

**476** ELECTROREFINING OF PLUTONIUM. Long, J. L.; Schweikhardt, R. D. (to U. S. Atomic Energy Commission). U. S. Patent 3,282,806. Nov. 1, 1966.

A process for the electrorefining of plutonium is described. Impure plutonium is melted with an electrolyte consisting of sodium chloride, potassium chloride, and magnesium chloride, and after stirring, electrolysis is initiated. Chemical action between the magnesium chloride and the plutonium provides plutonium ions to start the electrorefining process. (AEC)

## *Properties Evaluations*

*Refer also to abstracts 455 and 506.*

**477** (AD–640465) DAMPING CAPACITY OF MATERIALS. VOLUME I. Maringer, Robert E. (Battelle Memorial Inst., Columbus, Ohio). Jan. 3, 1966. Contract DA-01-021-AMC-11706 (Z). 388p. (RSIC–508 (Vol.1)). CFSTI $7.00 cy, $1.75 mn.

A brief introduction to the field of damping capacity in materials is presented along with an extensive, annotated bibliography. The fundamentals of damping, general methods of measuring internal friction or damping capacity, and some representative damping properties are given. The bibliography contains 1156 references to pertinent literature published from 1955 through 1960. (J.R.D.)

**478** (EURAEC–1642) [PREPARATION AND PROPERTIES OF STAINLESS STEELS]. Quarterly Report No. 3, January 1–March 31, 1966. Chaudron, G. (Centre National de la Recherche Scientifique, Paris (France)). Contract 059-65-7-TEEF (RD). 13p. (EUR–2841). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

Methods used in preparation of 18-10 stainless steel containing controlled quantities of C are described. The C was added as Fe–C with 1.8% C using vacuum melting. Steels containing several hundred ppM C were prepared. Investigations of stress corrosion testing of stainless steel revealed that reagents generally used in these tests contain traces of $Mg(ClO_3)_2$ which decomposes yielding $Cl_2$ upon heating. The free $Cl_2$ may lead to faulty corrosion test results. Results of investigations concerning the effects of Ni content on the mechanical properties of stainless steel containing 18% Cr are reported. The Ni content was varied between 5 and 14%. It was found that 14% Ni content is required for production of stable austenitic structure in this alloy. (J.R.D.)

**479** (GA–7233) A PROGRAM OF BASIC RESEARCH ON MECHANICAL PROPERTIES OF REACTOR MATERIALS. Quarterly Progress Report, February 1, 1966–April 30, 1966. Trozera, T. A.; Chambers, R. H. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). June 27, 1966. Contract AT(04-3)-167. 19p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Development of methods for evaluating neutron-induced changes in bcc metals is discussed. A major method selected is based on resistivity measurements using the value of the ratio of resistance at room temperature to that at 4.2°K. Sample resistance variations due to raw materials and zone refining parameters are discussed. Research is reported on the forces resisting the motion of dislocation segments such as edge, screw, geometrical kinks, and jogs. Data are included on damping spectra of high-purity Ta crystals and dislocation strain as function of temperature for deformed specimens of Nb, Fe, Ta, and W. Data are also included on transition metal dislocation activation energies and flaw stress vs temperature in these metals. (J.R.D.)

**480** (GEMP–440) IRON–CHROMIUM–ALUMINUM–YTTRIUM ALLOY FOR ELECTRICAL HEATING ELEMENTS. Stephan, H. R.; Collins, J. F. (General Electric Co., Cincinnati, Ohio. Nuclear Materials and Propulsion Operation). Oct. 18, 1966. Contract AT(40-1)-2847. 7p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Accelerated life tests of an Fe–25Cr–4Al–1Y alloy (GE-2541) conducted at 2200°F show this alloy containing Y to have superior life to that of a similar commercial Fe–19Cr–4Al alloy without Y. The GE-2541 alloy had an average life to burnout of 350 hours, (compared to 292 hours for the commercial alloy), only a slight increase in resistivity, and less than 4 percent elongation. Furthermore, the GE-2541 alloy forms an adherent oxide coating which restricts spalling when thermal cycled. These initial test data indicate this alloy has greater potential as high temperature heating elements than present commercial alloys. (auth)

**481** (KAPL–3158) FATIGUE DESIGN DATA FOR THE TITANIUM ALLOY, Ti–6Al–6V–2Sn. Mowbray, D. F. (Knolls Atomic Power Lab., Schenectady, N. Y.). May 20, 1966. Contract W-31-109-eng-52. 29p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

An investigation was conducted to determine some of the basic fatigue properties of the Ti-base alloy (Ti–6Al–6V–2Sn) in the annealed bar stock form. The basic S-N curves in the cyclic life region from approximately $10^2$ to $10^6$ cycles, the effect of mean stress at lives from $10^4$ to $10^6$ cycles, and the effect of notches on fatigue strength at $10^6$ cycles were established at room temperature and at 600°F. The test results indicate that this material possesses good unnotched fatigue strength, but has a rather high sensitivity to mean stress and notches. These latter results are as expected because of the material's high ratio of yield to ultimate tensile strength. The test results were analyzed in terms of current design methods. It was found that the effect of mean stress on the unnotched fatigue strength is best described by a parabolic damage law. Values of $\delta$ are established for estimating fatigue notch factors for members containing crack-like defects. (auth)

**482** (KAPL–3166) FRICTION TESTS BETWEEN $ThO_2$–$UO_2$ AND ZIRCALOY-4. Swota, J.; Wisnyi, L. G.; Schreiner, W. A. (Knolls Atomic Power Lab., Schenectady, N. Y.). Sept. 1966. Contract W-31-109-eng-52. 15p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Values for the coefficient of friction between 90 wt % $ThO_2$–10 wt % $UO_2$ material and reactor-grade Zircaloy-4 were determined as a function of surface condition for both the oxide material and the alloy material, the ambient temperature, and the applied load or pressure. The surface condition of the test materials and the test temperature, up to 750°F, had a significant effect on the coefficient of friction. Depending on the test conditions, values for the coefficient of friction ranged from 0.16 to 0.69. (auth)

**483** (NAA-SR-Memo–11680) THE DESIGN PROPERTIES OF HAYNES ALLOY NO. 25 (L–605). Ramsey, J. W. (Atomics International, Canoga Park, Calif.).

Oct. 21, 1965. Contract AT(11-1)-Gen-8. 27p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Many sources of data for Haynes Alloy 25 (L605) were analyzed and compared. The results are summarized and presented in six sections as follows: chemical composition, physical properties, mechanical properties, corrosion, manufacturing, and aging characteristics. Wherever possible, the typical mechanical properties at room temperature and at elevated temperatures were scaled to be consistent with the guaranteed minimum properties. In the cases where there are no guaranteed properties, e.g., modulus of elasticity, thermal conductivity, etc., the best average was made using data from several investigators. (auth)

**484** (NYO-2504-15) ELASTIC CONSTANTS OF METALLIC SODIUM. Martinson, Riho Hans (Cornell Univ., Ithaca, N. Y.). May 17, 1966. Contract AT(30-1)-2504. 145p. Dep. mn. CFSTI $4.00 cy, $1.00 mn.

Thesis.

The variation with temperature and pressure of the velocity of 10-Mc elastic waves propagating in monocrystalline metallic sodium was studied. The pressure dependence was measured at 78°K, 195°K, 273°K, and 299°K to pressures ranging from 4.5 to 9 kilobars. At atmospheric pressure, measurements of the temperature dependence extended from 78°K to 299°K. Although the dependence of the adiabatic elastic constants on the intensive thermodynamic variables is substantially linear throughout much of the domain investigated, small nonlinearities were observed at low temperatures and at the higher pressures. The observed values of the athermal second order elastic constants of sodium agree fairly well with Fuchs' theoretical predictions, although the direct ion core interactions in metallic sodium appear to be somewhat larger than those pertinent to the sodium halides. Experimentally accessible combinations of the third order elastic constants of sodium have been calculated by a simple extension of the method of Wigner and Seitz. Fair agreement is obtained at 0°K with the extrapolated experimental values. (auth)

**485** (RSIC-508(Vol.2)) DAMPING CAPACITY OF MATERIALS. Maringer, Robert E. (Battelle Memorial Inst., Columbus, Ohio). Jan. 3, 1966. Contract DA-01-021-AMC-11706(Z). 388p. CFSTI $7.00 cy, $1.75 mn.

This report contains a brief introduction to the field of damping capacity in metals and an extensive, annotated bibliography. The introductory material presents the fundamentals of damping, general methods of measuring internal friction or damping capacity, and some representative damping properties. The bibliography contains over 2300 references to pertinent literature published from 1955 through 1965, and is cross-indexed by both author and subject. (auth)

**486** (UCRL-14863) EFFECT OF STRESS STATE ON FLOW AND FRACTURE OF SEVERAL HIGH-STRENGTH ALLOYS. Zaslawsky, Maurice (California Univ., Livermore. Lawrence Radiation Lab.). Apr. 27, 1966. Contract W-7405-eng-48. 38p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Stress-strain data were obtained under uniaxial and equal biaxial stresses on ten high-strength materials: seven tool steels, two maraging steels, and a beta Ti. From the results it is shown that the strength of a material under biaxial stress cannot be predicted on the basis of its strength under uniaxial stress. (auth)

**487** PLASTIC DEFORMATION OF TUNGSTEN SINGLE CRYSTALS AT LOW TEMPERATURES. Argon, A. S.; Maloof, S. R. (Massachusetts Inst. of Tech., Cambridge). Acta Met., 14: 1449-62(Nov. 1966).

The plastic deformation of both strain-anneal grown and melt-grown W single crystals of various orientations and high purity was investigated at 77 to 450°K. It is concluded that the temperature sensitive yield strength is due to a lattice friction stress. The very high rates of strain hardening in all orientations can neither be due to the building up of an internal stress, nor due to the accumulation of defects on screw dislocations; it must be due to an insufficiently understood process of exhaustion of mobile dislocations. An anisotropy of the lattice friction stress exists on the {112} planes which produces slip on unexpected slip systems and gives rise to different flow stresses in tension and compression in [001] and [110] oriented crystals. (auth)

**488** FRACTURE OF TUNGSTEN SINGLE CRYSTALS AT LOW TEMPERATURES. Argon, A. S.; Maloof, S. R. (Massachusetts Inst. of Tech., Cambridge). Acta Met., 14: 1463-8(Nov. 1966).

The fracture behavior of both strain-anneal grown and melt-grown W single crystals of high purity was investigated in the temperature range of 77°K and room temperature. It was found that in the absence of surface defects and weak boundaries, crystals of all orientations rupture at room temperature by thinning down to a knife edge. At 199°K a transition between rupture and cleavage fracture is observed in some orientations as a result of high strain concentrations at rupture notches. At 199°K and below twinning limits ductility by crack nucleation at the intersection of two twin bands with non-parallel twinning directions. It was observed also that interaction of non-coplanar twins of one family alone could give rise to cracks. The evidence is consistent with the formation of sub-critical size cracks before final fracture which have to await the fulfillment of a fracture propagation condition. (auth)

## *Structure and Phase Studies*

*Refer also to abstracts 455 and 506.*

**489** (AD-639603) THE MICROSTRAIN REGION IN HIGH-PURITY REFRACTORY METALS. Quarterly Report No. 2, June 1, 1966–August 31, 1966. Prekel, H. L.; Lawley, A.; Meakin, J. D. (Franklin Inst. Research Labs., Philadelphia, Pa.). Contract Nonr-4434(00). 18p. (Q-B2195-2). CFSTI $1.00 cy, $0.50 mn.

It is shown that $H_2$ annealing treatments which are required in the preparation of Mo single crystals suitable for dislocation velocity experiments leave the remaining dislocations in an unpinned state. Some tentative dislocation velocity determinations are presented leading to an activation volume $v^* \sim 20b^3$ in agreement with values of $v^* = 15b^3 - 25b^3$ found by strain-rate change experiments in the macro-strain region. The micro-strain behavior of Mo single crystals treated in $H_2$ in a similar fashion is examined. The true elastic limit $\tau_E$, the dissipative friction stress $\tau_F$, and the activation volume $v^*$ are found to be: $\tau_E = 0.07 \pm 0.002$ Kg mm$^{-2}$, $\tau_F = 0.04 \pm 0.002$ Kg mm$^{-2}$ and $v^* \sim 1700b^3$. These results are compared to those obtained with zone-refined crystals. (auth)

**490** (EURAEC-1700) STUDY OF THE BASE METAL INTENDED FOR RESEARCH ON THE BRITTLE FRACTURE OF LARGE WELDMENTS. Quarterly Report No. 9, April 1–June 30, 1966. (Institut de Recherches de la Siderurgie, St. Germaine-en-Laye (France)). Aug. 1966. Contract 031-64-5-TEEF (RD). 7p. (EUR-2887). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

Results of studies concerning fast transformations in specimens of AMMO steel during separate tests of fast heating to 900, 1000, 1100, and 1250°C with immediate cooling after each heat application. Resulting data obtained by magnetic and thermal analyses are presented as transformation curves. (J.R.D.)

**491** (LA-3526) STRUCTURE IN LIQUID Au–Cd AND Ce–Cd SOLUTIONS. VAPOR PRESSURE AND ELECTRICAL RESISTIVITY. LIQUID COMPOUNDS, TWO-LIQUID REGIONS, PREMONITORY PHENOMENA, AND FREEZING. Elliott, Guy R. B.; Herrick, Claude C.; Lemons, Joe Fred; Nordine, Paul C. (Los Alamos Scientific Lab., N. Mex.). Mar. 1, 1966. Contract W-7405-eng-36. 40p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The electrical resistivity of liquid Cd and Au–Cd solutions and the vapor pressures of Au–Cd and Ce–Cd solutions were measured. The existence of extensive solid-like structure in these strongly bonded liquids is indicated by these measurements. Liquid compounds and premonitory phenomena are demonstrated. Melting and freezing are discussed in light of the premonitory phenomena. (auth)

**492** TUNGSTEN DEPOSITION FROM TUNGSTEN MESH HEATING ELEMENT IN VACUUM ABOVE 2450 DEG K. Messier, D. R.; Hurum, W. H. (Argonne National Lab., Ill.). Rev. Sci. Instrum., 37: 1610-11(Nov. 1966).

In a series of blank runs on an empty tungsten Knudsen cell at high temperatures, a surprising but reproducible cell weight gain in each run was observed. The cell was heated by a W mesh heating element, and weight changes were measured with a recording microbalance. Weight gain rates were measured in the temperature range from 2450 to 2625°K in a vacuum of $2 \times 10^{-6}$ Torr. Linear rates were observed for times as long as 18 h. (auth)

**493** EFFECTS OF MOLYBDENUM ON SOLID-STATE TRANSITIONS IN VANADIUM–TANTALUM ALLOYS. Grigor'ev, A. T.; Sokolovskaya, E. M.; Nefedov, A. P.; Sokolova, N. G. Vestn. Moskov. Univ., Ser. II: Khim., No. 4, 44-9(July-Aug. 1965). (In Russian).

The effects of addition of Mo to the V–Ta system was studied by microscopic and by high-temperature contactless thermal analyses, hardness and microhardness tests, and solidus temperature determinations on mixtures of various compositions. At high temperatures Mo solubility was unlimited, as shown by the solidus line of the phase diagram, the absence of breaks in the hardness curves, and the absence of thermal effects from 1400 to 1600°C on the differential heating curve of annealed alloys. X ray analysis showed that there occurred a regularizing process, related to formation of a crystalline phase whose structure was the same as that of $TaV_2$ formed in the binary V–Ta system. Phase diagrams constructed from the data obtained for the V–Ta–Mo system are presented together with photographs of the microstructure. (TTT)

**494** SOLID-STATE PHASE TRANSFORMATIONS IN VANADIUM–TANTALUM ALLOYS. Nefedov, A. P.; Sokolovskaya, E. M.; Grigor'ev, A. T.; Chechernikov, V. I.; Sokolova, I. G.; Guzei, L. S. Vestn. Moskov. Univ., Ser. II: Khim., No. 5, 42-7(Sept.-Oct. 1965). (In Russian).

V–Ta alloys form a continuous series of solid solutions, with the solidus and liquidus lines reaching a minimum at 1825°C with 15 at. % Ta. The magnetic susceptibility depends on the temperature, according to the Curie–Weiss law, and measured values of it indicated that d electrons remain localized. The compound $TaV_2$ appeared to form on long annealing of a 2-to-1 (at. %) V–Ta mixture. This compound was shown by x ray analysis to have a hexagonal structure similar to the crystalline phase of $MgZn_2$, with a = 5.058 Å, c = 8.250 Å, and c/a = 1.631. Its magnetic susceptibility was not temperature dependent. Concentration and temperature limits for the existence of $TaV_2$ in a binary system are shown graphically, and photomicrographs are presented to show the microstructure. All results obtained are consistent with each other. (TTT)

**495** NIOBIUM REACTIONS WITH RUTHENIUM. Panteleimonov, L. A.; Nesterova, O. P.; Guts, Z. A.; Akhmetzyanov, K. G.; Sokolova, I. G. Vestn. Moskov. Univ., Ser. II: Khim., No. 6, 57-62(Nov.-Dec. 1965). (In Russian).

The Nb–Ru system was investigated by means of microscopic and x-ray diffraction analysis, hardness and microhardness determinations in the 50 to 700°C range, and by thermal conductivity measurements in the 25 to 500°C range. The homogenized alloy specimens were quenched in water from 1500°C after soaking for 10 hours. The alloys corresponding to the compound NbRu at the minimum of the solidus line exhibited a solid-solution while the other alloys had a dendritic nature. Alloys containing up to 56 at. % of Ru were polyhedric. The Vickers hardness of annealed and quenched specimens did not differ markedly. The 40 at. % Ru alloy had a volume-centered cubic lattice, the 42 at. % Ru alloy had a tetragonal had an ordered tetragonal one. The high-temperature modification of Ru had a hexagonal structure, the low-temperature modification a close-packed hexagonal one. In the 0 to 50 at. % Ru range the minimum of the solidus line, the electrical conductivity curve, the temperature coefficient of the electrical resistivity, the maximum of the hardness curve, and the transition of the face-centered cubic lattice into a tetragonal one corresponds to the same composition of about 40 at. % of Ru. (TTT)

**496** RUTHENIUM REACTIONS WITH TANTALUM. Panteleimonov, L. A.; Nesterova, O. P.; Akhmetzyanov, K. G.; Sokolova, I. G. Vestn. Moskov. Univ., Ser. II: Khim., No. 6, 63-8(Nov.-Dec. 1965). (In Russian).

Microchemical, x-ray diffraction methods, hardness and microhardness measurements, and melting-point and electric conductivity measurements in the 50 to 700°C range were used for the investigation of ruthenium–tantalum alloys. The alloys were prepared in an arc furnace, in argon atmosphere at a pressure of 300 mm of Hg, the homogenized specimens were quenched in water from 1800, 1500, and 1400°C, and annealed in vacuum. The specimens for electric conductivity measurements were prepared by powder metallurgy, resulting in rods with 88% theoretical density. Alloys corresponding to the composition of the compound TaRu and those near the minimum of the solidus line (45 atomic % Ru) were found to possess a solid-solution structure and a nearly polyhedral one, respectively; the other alloys had a dendritic structure. X-ray diffraction studies revealed that TaRu quenched from 1500°C possessed a primitive rhombic structure with the following parameters: a = 4.351 ± 0.005; b = 4.226 ± 0.005; and c = 3.372 ± 0.005 Å; the 47 at. % Ru alloy had a similar structure. The 46 at. % Ru alloy exhibited an ordered tetragonal structure. Hexagonal structure was found in alloys based on the high-temperature modification of ruthenium containing 79 at. % Ru. In the 0 to 50 at. % Ru range, the minimum of the solidus curve, the maximum of the hardness curve and transition of the volume centered cubic lattice into the tetragonal one corresponded to the nearly the same composition between 44 and 45 at. % of ruthenium. (TTT)

**497** STRUCTURE OF THE $ZrCr_2$–$TaCr_2$ SYSTEM. Gebhardt, E.; Rexer, J. (Max-Planck-Institut fuer Metallforschung, Stuttgart). J. Less-Common Metals, 11: 295-6(1966). (In German).

A temperature-concentration cross section between the binary compounds $ZrCr_2$ and $TaCr_2$ in the Zr–Ta–Cr alloys was determined. The formulation of this cross section was based on the results of thermal analysis, hardness measurements, and structure observations. The constitution diagram of the system is given and the lattice structure of the (Zr,Ta) $Cr_2$ mixed crystal is determined. (J.S.R.)

**498** PHASE TRANSFORMATION DAMAGE IN PLUTONIUM. Nelson, R. D. (Battelle-Northwest, Richland, Wash.). Contract AT(45-1)-1830. J. Nucl. Mater., 20: 153-61(Aug. 1966).

Pu may contain large volumes of microcracks which form during the $\beta \rightarrow \alpha$ transformation. The volume of microcracks increases with increasing transformation temperature, metal purity, specimen size, and applied uniaxial tensile stress. Transformation cycling causes additional microcracking, with concomitant swelling in all directions and extensive surface rumpling. For a given $\beta \rightarrow \alpha$ transformation temperature, more damage occurs if the parent beta was formed from alpha rather than gamma. Alpha Pu containing no microcracks can be produced by quenching the beta phase to –75°C during casting. No physical damage occurs during $\gamma \approx \beta$, $\delta \approx \gamma$, or $\delta \approx \beta$ transformation cycling if the metal initially contains no microcracks. (auth)

## *Radiation Effects*

*Refer also to abstracts 836 and 1155.*

**499** (ANL-6832) EXAMINATION OF EBWR CORE-1A FUEL. Carlander, R. (Argonne National Lab., Ill.). June 1966. Contract W-31-109-eng-38. 15p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

An EBWR fuel element was examined, after operation at 100 MW and a maximum burnup of 0.61 at. %, as part of a continuing evaluation of the in-reactor performance and irradiation damage to the fuel alloy. Although the maximum rate of volume increase per at. % burnup was 7.6% at the point of maximum burnup, increases as high as 13.3% per at. % burnup were found in regions of lower burnup. These larger rates of volume increase were due to a combination of burnup and high centerline fuel temperature. Large-scale buildups, particularly in regions free of nucleate boiling, contributed to the higher centerline fuel temperatures by acting as a thermal insulation barrier between the cladding and the water coolant. The temperatures, which were calculated to be in excess of 500°C, resulted in an annealing out of the residual stresses that existed in the fuel elements before the 100-MW operation. The results indicated that for satisfactory performance at high power levels, the centerline fuel temperature of fuel elements of the EBWR type should be maintained below 500°C through the adequate control of scale accumulation. (auth)

**500** (DP-1060) INFLUENCE OF THERMAL RATING AND BULK DENSITY ON IRRADIATION PERFORMANCE OF FUSED $UO_2$ TUBULAR FUEL ELEMENTS. Cole, G. Rolland (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.). Aug. 1966. Contract AT(07-2)-1. 24p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Mechanically compacted tubes of fused and ground $UO_2$ in Zircaloy sheaths, with bulk densities between 82 and 90% of theoretical, were irradiated in the Heavy Water Components Test Reactor (HWCTR) to 3500 MWd/$Te_u$ at thermal ratings up to 50 Watts/cm. Fission gas release up to 60% and extensive columnar grain growth occurred in elements operating at thermal ratings of approximately 40 to 50 Watts/cm. Gas release was not significantly affected by bulk density. The tubes of lower density, 82 to 87%, that operated at the higher thermal ratings experienced substantial decreases in core volume and formed a lengthwise ridge in the outer sheath. (auth)

**501** (EURAEC-1702) IN-PILE CORROSION OF NUCLEAR MATERIALS. Quarterly Report No. 4, December 1, 1965-February 28, 1966. (Centre d'Etude de l'Energie Nucleaire, Mol (Belgium)). Contract 055-65-3 TEEB (RD). 19p. (EUR-2888; R-2388). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Work Performed under United States-Euratom Joint Research and Development Program.

In order to determine the effects of radiolysis of water on the electrochemical potential of steel and Pt, the potential changes of these metals have been measured in solutions containing ferrous and ceric ions. It has been found that the potential of Pt in a solution of $Fe^{3+}$ and $Ce^{4+}/Ce^{3+}$ by gamma irradiation may show a drop of about 700 mV indicating reduction of the ceric ions. Steel in the same solution sometimes also indicates a potential decrease by gamma irradiation of the solutions. However, the results are obscured by the ability of steel to reduce excess ceric ions. A potential rise in solutions of $Ce^{3+} + Fe^{3+}/Fe^{2+}$ has not been found during the applied irradiation times (65 hours at $1.68 \times 10^5$ RAD/hr). Addition of an organic impurity to the water (ethyl alcohol) further decreases the electrochemical potential of Pt. The Pt potential in that case corresponded to that of the hydrogen electrode. It was again not definite whether alcohol addition affected the potential of steel. The potential drops observed were less pronounced than in the case of Pt. Analysis of the solution and the oxide on 18/8 stainless steel and the $H_2SO_4$ solution used for coulometric reduction of the oxide has shown that chromium oxide may dissolve. Potential-time curves measured during reduction of oxide films on pure chromium showed two distinctive steps in the reduction process. (auth)

**502** (GEAP-5126) HIGH POWER DENSITY DEVELOPMENT PROJECT. Quarterly Progress Reports No. 23 and 24, December 1965-May 1966. Howard, C. L.; Duncan, R. N. (comps.) (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). June 1966. Contract AT(04-3)-361. 24p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Twenty-two developmental fuel assemblies accumulated exposure as part of an 64-bundle core in the Consumers Big Rock Point reactor until a scheduled shutdown on April 8, 1966. During the April 1966 reactor shutdown, several of the developmental assemblies were visually inspected. Selected fuel rods were removed from these assemblies, dimensional profiles were obtained, and the fuel rods were reinserted for continued irradiation. Two of the eight Group I developmental assemblies, PE-3 (Type-304L stainless steel cladding, collapsed 0.010-inch-wall, swaged-over-pellet $UO_2$) and PO-2 (Type-304L stainless steel cladding, collapsed 0.010-inch-wall, swage compacted powder $UO_2$), were part of this core loading, and were suspected of containing failed fuel rods. Visual inspection of the PE-3 assembly indicated that at least five fuel rod failures had occurred. Two peripheral fuel rods and three interior fuel rods were verified as being failed. Visual inspection of the PO-2 assembly revealed a minor suspect region on one fuel rod. Penetration of the cladding at this one area could not be verified by the visual examination. Visual inspection of other developmental assemblies containing fuel rods with Zircaloy-2, Incoloy-800, and Inconel-600, and fabricated by various processes, revealed no failed fuel rods. Nonuniform crud deposition was observed on all peripheral fuel rods. Variations in the appearance of the crud deposits were observed both along the length of the fuel rods and around the circumference. Dimensional profiles were obtained on fuel rods removed from the above assemblies and then reinserted into the assemblies for continued irradiation. Increases in the diameter and ovality of fuel rods were measured. Analysis of these data indicates that the fuel rod diameter increases and ovality are due to nonuniform adherent crud deposition. Cladding deformation may have occurred but cannot be measured due to the adherent crud deposits on most of the fuel rod surfaces. (auth)

**503** (KFK-396) SICHERHEITSBERICHT FUER BR2-MATERIAL-BESTRAHLUNGSVERSUCHE, PROJEKT MOL 2. UNTERSUCHUNG DES KRIECHVERHALTENS VON CAN-MATERIALIEN UNTER BESTRAHLUNG. (Safety Report for BR2 Material Irradiation Experiment, Project Mol 2. Study of Creep Behavior of Can Material Under Irradiation). Gast, K.; Kramer, W. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorentwicklung). Oct. 1965. 37p. Dep. mn.

The creep behavior of can material under irradiation is to be tested. The experimental procedure, conditions, and safety precautions are described in detail with consideration of the construction and manipulation of the irradiation capsule, the transportation of the irradiated cans from Karlsruhe to Mol, and preliminary testing of the experimental technique. Safety considerations during the analysis of the irradiated can materials are discussed. (J.S.R.)

**504** (LAC-ER-8673) EFFECT OF NUCLEAR RADIATION ON MATERIALS AT CRYOGENIC TEMPERATURES. Quarterly Report No. 4, April 21-July 21, 1966. (Lockheed Nuclear Products, Marietta, Ga.). Aug. 1966. Contract NAS-3-7985. 94p. (NASA-CR-72056).

The studies include the effects of (1) $10^{18}$n/cm$^2$ (E > 0.5 MeV) at 30°R on tensile properties of Ti-base alloys; (2) irradiation temperature (30°R to 540°R) on tensile properties of Al-1099-H14 following irradiations up to $3 \times 10^{17}$ n/cm$^2$ (E > 0.5 MeV); (3) annealing following irradiation at 30°R to $10^{17}$n/cm$^2$ (E > 0.5 MeV) on tensile properties of Al-1099; and (4) irradiation at 30°R on axial, low-cycle fatigue properties of Ti-base alloys. All out-of-pile tensile testing and in-pile testing of Al-1099, Ti-55A, Ti-5Al-2.5 Sn (ELI) and Ti-6Al-4V (Annealed) has been completed. The recovery for the previously reported cryogenic depres-

sion of the $F_{ty}/F_{tu}$ ratio in Al-1099-H14 (unirradiated) was observed to be an essentially linear function of irradiation level. After $3 \times 10^{17}$n/cm$^2$ (E > 0.5 MeV), this parameter at 30°R is over 70% of its initial room temperature value, indicating a similarity between irradiation effect and work hardening. It was observed that there was no significant difference between the mechanical properties of Al-1099 after irradiation to $10^{17}$n/cm$^2$ (E > 0.5 MeV) at 30°R followed by annealing and testing at several higher temperatures, and the same properties from specimens, both irradicted to $10^{17}$n/cm$^2$ (E > 0.5 MeV) and tested at the higher temperatures. However, significant variation was observed between the residual irradiation effects after annealing when tested at the annealing temperature and when re-cooled to the irradiation temperature prior to test. Increases in strength functions, accompanied by moderate reductions in ductility, were observed in the three Ti alloys for which testing was complete. There was no evidence of saturation at $10^{18}$n/cm$^2$ (E > 0.5 MeV). (D.L.C.)

**505** (NRL-6419) NEUTRON IRRADIATION EMBRITTLEMENT OF SEVERAL HIGHER STRENGTH STEELS. Steele, L. E.; Hawthorne, J. R.; Gray, R. A. Jr. (Naval Research Lab., Washington, D. C.). Sept. 7, 1966. Contract AT(49-7)-2435. 20p. (CONF-660607-4). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 3rd International Symposium on the Effects of Irradiation on Structural Metals, Atlantic City.

Several steels representative of recently developed types and having potential for nuclear structural applications were exposed to high energy nuclear radiation, and the resultant properties were compared with those of the currently used A212-B and A302-B nuclear reactor pressure vessel steels. Preliminary results from several comparative irradiation experiments indicate that certain higher strength steels, in addition to having initial qualities of higher strength and lower initial ductile-brittle transition temperatures, show smaller embrittlement, earlier embrittlement saturation, and a superior overall response to irradiation at 550°F than that observed for the steels in current reactor pressure vessels. (auth)

**506** (ORNL-4020) RADIATION METALLURGY SECTION SOLID STATE DIVISION PROGRESS REPORT FOR PERIOD ENDING JULY 1966. (Oak Ridge National Lab., Tenn.). Sept. 1966. Contract W-7405-eng-26. 64p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Investigations on the response of weld heat-affected-zone samples of ASTM A-212B pressure-vessel steel reveal that heat-affected-zone samples show a higher ductile-brittle transition temperature after irradiation and are less responsive to post-irradiation annealing than base plate specimens. Studies of the effect of neutron irradiation and post irradiation annealing on the tensile properties show that annealing of radiation hardening takes place at 300 to 600°C. An analysis was developed to determine the ductile-brittle transition temperature of metals in terms of experimentally obtainable grain size parameters. Results of stress-strain tests on Ferrovac-E specimens after neutron irradiation at 55 to 90°C suggested that radiation hardening may be viewed as equivalent to strain hardening. Dislocation tangles form in Ferrovac-E at lower strains in irradiated specimens than in unirradiated specimens; these may be a consequence of dislocation channeling. The effect of specimen purity on the flow stress of Nb single crystals was studied using tensile specimens cut from rods given various numbers of zone refining passes. For Nb prepared from Wah Chang starting stock the lower yield shear stress dropped from 2.5 kg/mm$^2$ after 1 pass to 1.6 kg/mm$^2$ after 4 passes. Further numbers of passes up to 12 caused little change in the flow stress. Similar effects were observed using DuPont Nb starting material. The effect of neutron irradiation on the plastic deformation of Nb single crystals is being studied. Results indicate that the dislocation velocity at the upper yield point is about the same in both unirradiated Nb and irradiated Nb. It was also found that the dislocation velocity at the lower yield stress is a factor of six greater in irradiated Nb than in unirradiated Nb, and that the mobile dislocation density at the lower yield stress is a factor of six less in the irradiated Nb than in the unirradiated Nb. Nb containing O, N, and C as interstitial impurities was irradiated at 50°C, and then annealed. Internal friction measurements showed that upon warming the O interstitials which are the most mobile of the three species migrate to radiation produced defects and are effectively removed from the normal lattice sites. It was concluded that this process is responsible for the stage III changes of resistivity and yield stress. Progress towards completion of the design of a fission flux neutron convertor irradiation facility is described. (J.R.D.)

**507** (RCN-57) LOW TEMPERATURE IRRADIATION OF STEELS FOR REACTOR PRESSURE VESSELS. Hanevik, A.; Larsen, T. (Institutt for Atomenergi, Kjeller (Norway)). July 1966. 40p. Dep. mn.

Radiation damage in different pressure vessel steels was studied at fast neutron fluxes between $5 \times 10^{17}$ and $10^{20}$ n/cm$^2$ at 60°C. The steels irradiated were T-1 (American), Ducol W-30 (English), R3/2103 (Swedish), and 1.2 MD07 (French). The change in tensile and impact strength properties was determined. A saturation of the radiation damage occurs for fast fluxes 3 to $5 \times 10^{19}$ n/cm$^2$. The following equations for the increase in transition temperature ($\Delta T$) and increase in lower yield strength ($\Delta\sigma$) as functions of fast flux ($\phi_f$) agree with experiment $\Delta T = A(1-e^{-B\phi f})^{\frac{1}{4}}$ and $\Delta\sigma = C(1-e^{-D\phi n})^{\frac{1}{4}}$. (D.L.C.)

**508** PHOTOCONDUCTIVITY SPECTRA OF GERMANIUM SINGLE CRYSTALS IRRADIATED WITH GAMMA QUANTA. Sevchenko, A. N.; Tkachev, V. D.; Urenev, V. I. (Belorussian State Univ., USSR). Dokl. Akad. Nauk BSSR, 10: 550-2(1966). (In Russian).

An investigation was made of the system of energy levels that appears in n-type and p-type Ge single crystals irradiated with gamma quanta from $^{60}$Co at room temperature. Particular attention was given to a study of the stable centers, which introduce deep energy levels into the forbidden zone. Photoconductivity spectra were taken in a range from 1 to 5 $\mu$ for temperatures from 300 to 80°K before and after irradiation with integrated fluxes of $10^{14}$ to $5 \times 10^{17}$ kv/cm$^2$. The initial specific resistances of the n- and p-type crystals were 48 and 6 ohm cm, respectively. The concentration of residual impurities in the electrically active state for n-type material was $10^{12}$ to $10^{13}$ cm$^{-3}$. Investigation of the electrical characteristics of specimens after irradiation showed the presence of $E_v$ + 0.01, + 0.008, and + 0.17 eV levels in p-type Ge and $E_c$ − 0.20 eV level in n-type Ge. Irradiation of n-type crystals with doses up to $5 \times 10^{17}$ kV/cm$^2$ did not change the conductivity sign. At T = 80°K the Fermi level in irradiated n-type specimens was located 0.16 to 0.22 eV from the bottom of the conductivity zone, while in p-type specimens it was found 0.20 to 0.26 eV from the top of the valence zone. The presence of deep centers in both irradiated and nonirradiated crystals indicated that these centers are not generated due to the irradiation but are only displayed as the result of it. The transition of electrons between the zones and these centers in irradiated crystals can lead to a significant change in the concentration of free carriers since after irradiation the equilibrated concentration of free carriers becomes very low as a result of their capture by the radiation damage, which introduces shallower energy levels. Therefore in irradiated specimens for which the ratio $\Delta\sigma/\sigma$ is greater, it is possible to detect deep energy levels, which belong to residual imperfections of the crystal lattice. (ATD)

**509** EJECTION OF URANIUM ATOMS FROM ELECTROPOLISHED FOILS OF URANIUM METAL BY FISSION FRAGMENTS. Nilsson, G. (Aktiebolaget Atomenergi, Stockholm). J. Nucl. Mater., 20: 231-5(Aug. 1966).

The emission of U atoms from the surface of electropolished discs of U metal irradiated to about $2.3 \times 10^{16}$ fis-

sions/cm$^3$ at a pressure of $10^{-5}$ Torr was measured. The atoms emitted were collected on catcher foils and the amount collected was determined by fission counting. The number of U knock-ons ejected by a fragment was calculated. The number of U atoms emitted per escaping fission fragment was found to be about 43 which is of the same order of magnitude as the number of U knock-ons ejected by a fragment. Other ejection mechanisms, e.g., evaporation of material in thermal spikes, seem to be of little importance. (auth)

**510** X-RAY STUDIES OF NEUTRON BOMBARDMENT INFLUENCE ON THE REAL STRUCTURE OF GERMANIUM. Auleytner, Julian (Inst. of Physics, Warsaw); Krylow, Janusz; Psoda, Marek; Szarras, Stanislaw. Nukleonika, 11: 393-8(1966).

The dislocation distribution and density in as-grown and plastically deformed Ge single crystals before and after fast neutron bombardment (dose about $2 \times 10^{19}$ neutrons/cm$^2$) were studied. An x-ray spectrometer with oscillating film was used for measurements. No changes of dislocation density in as-grown specimens were observed after irradiation. In plastically deformed crystal changes of disorientation of mosaic blocks in the range of ±1 minute of arc and the increase of dislocation density within the blocks were found. (auth)

**511** MODULUS EFFECTS IN METALS AFTER LOW TEMPERATURE ELECTRON IRRADIATION. II. Au. Keefer, D. W. (Atomics International, Canoga Park, Calif.); Robinson, J. C.; Sosin, A. Contract AT(11-1)-Gen-8. Acta Met., 14: 1409-20(Nov. 1966).

Isochronal measurements show only small amounts of dislocation pinning occurring between 4.2 and about 180°K. Two pinning stages, centered at about 200 and 320°K, are observed. These are attributed to interstitials and vacancies, respectively. Damage rate measurements performed at 20°K show that dislocation pinning can be effected by focussons at electron energies below that required for atomic displacement in the lattice. Prolonged damage production results are fitted by assuming the presence of two dislocation components. These components appear to be similar to those detected previously in Cu. (auth)

**512** STUDY OF THE RETURN OF THE RESISTIVITY OF Nb IRRADIATED WITH ELECTRONS AT 20 DEG K. Pichon, R.; Minier-Cassayre, C.; Hivert, V.; Moser, P. (CEN, Grenoble, France). Phys. Status Solidi, 17: K33-5(1966). (In French).

Electron-irradiated Nb presents well defined stages for the restoration of the resistivity. After irradiation of $5 \times 10^{17}$ electrons at 3 Mev/cm$^2$ the samples were exposed to thermal treatment and the evolution of the resistivity and its derivatives was determined. Four peaks of restoration acceleration were detected. The peak at 40°K seems to depend on the impurity concentrations. The peak below 100°K is attributed essentially to the annihilation of interstitials. The peak at 335°K corresponds to a rearrangement of fault-impurity complexes. (J.S.R.)

**513** IRRADIATION DAMAGE TO SOLIDS. Kelly, B. T. The Commonwealth and International Library. New York, Pergamon Press, 1966. 248p. $4.50.

A review of the effects produced in crystalline solids by irradiation includes chapters on the following: calculations of the number of atoms displaced from their normal lattice sites by different types of irradiation, the behavior of the displaced atoms and the associated vacant lattice sites, changes in physical properties of solids produced by these displaced atoms, and the annealing of the damage after irradiation. The problem of carrying out adequate irradiation testing of materials particularly with reference to nuclear reactors is considered briefly. (A.G.W.)

# Ceramics and Cermets

## Corrosion and Erosion

*Refer also to abstracts 447, 453, and 1155.*

**514** (CONF-611003-1) SILICON-SILICON CARBIDE COATINGS ON GRAPHITE. Carpenter, R. W. (Aerojet-General Nucleonics, San Ramon, Calif.). [nd]. Contract AT(10-1)-880. 13p. (AN-ENGR-42). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From American Ceramic Society, Pacific Coast Regional Meeting, San Francisco, Calif.

Samples of grade ATJ and A graphite were outgassed and then coated successively with SiC and Si. The SiC was formed from Si by heating to just above its melting point. Oxidation tests were conducted in air at 1000°C, and the coating structure was examined. The results show that the coating will prevent oxidation of graphite in 1000°C air for 10,000 hr under isothermal and mild thermal cycling conditions. (D.L.C.)

## Preparation and Fabrication

*Refer also to abstracts 447, 467, and 1221.*

**515** (NUMEC-3505-18) $PuO_2$-$UO_2$-$ZrO_2$ FUEL DEVELOPMENT PROGRAM. Progress Report, March 1-June 30, 1966. (Nuclear Materials and Equipment Corp., Apollo, Pa.). July 29, 1966. Contract AT(30-1)-3505. 33p. (EURAEC-1706). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Work Performed under United States-Euratom Joint Research and Development Program.

The program includes synthesis of the fuel powders, fabrication of pellets, characterization of powders and pellets, and irradiation performance testing of selected fuel compositions. (J.R.D.)

**516** (TID-23388) EFFECTS OF NEUTRON DAMAGE ON THE MECHANICAL PROPERTIES OF PYROLYTIC AND SINGLE CRYSTAL GRAPHITE. Annual Progress Report, July 1, 1965-June 30, 1966. Meers, J. T. (Union Carbide Corp., Parma, Ohio. Carbon Products Div.). July 15, 1966. Contract AT(40-1)-3237. 51p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

An analysis was made of the optical reflectivity method for measuring the c-axis misorientation of pyrolytic graphite. The static shear apparatus was revised to allow measurement of both shear modulus and shear strength of single crystals. The ultrasonic method was also used successfully for the determination of the shear modulus of single crystals. The static torsion apparatus for the testing of pyrolytic graphite was automated to make the testing more convenient. Calculations were made to determine the feasibility of measuring $c_{13}$ on compression-annealed pyrolytic graphite; with present measuring techniques, a reliable value of $c_{13}$ probably cannot be obtained directly from experiment. Specimens for the irradiation program were prepared; results of the preirradiation tests are reported. (auth)

**517** HOT-PRESSING OF URANIUM DIOXIDE. Amato, I.; Colombo, R. L.; Petruccioli Balzari, A. M. (FIAT, Turin). J. Nucl. Mater., 20: 210-14(Aug. 1966).

$UO_2$ powder was vacuum hot-pressed at 4000 to 8000 psi and 1100 to 1400°C. End-point densities were achieved and found to depend primarily on the mechanism of densification (which is likely that of McClelland) and only at very high densities on the presence of gases occluded in the pores. A figure for the critical shear stress at 1100°C is given. (auth)

**518** NUCLEAR FUEL ELEMENT MADE OF A CERAMIC METAL COMPOSITE MATERIAL AND METHOD FOR CLOSING THE ENDS OF THE SAID ELEMENT. Agace, Carlo; Klersy, Raymond; Musso, Giuseppe; Parisotto, Angelo; Schrader, Karl; Alfille, Lucien (to EURATOM). Canadian Patent 741,416. Aug. 23, 1966. Priority date Aug. 6, 1963, Belgium.

A method is described for obtaining a tight closure of fuel sheaths made of ceramic-metal materials which cannot be melted without destroying desirable structural properties. Plugs are firmly secured in the ends by means of a thin ring, threads in tube, and a plug. The ring is elec-

tron bombarded while the tube and ring assembly is rotated slowly. Only the ring melts. Materials and critical dimensions are detailed. (F.S.A.)

**519** ULTRAHIGH PURITY CARBIDE FORMATION. Riley, Robert E.; Davidson, Keith V. (to U. S. Atomic Energy Commission). U. S. Patent 3,284,550. Nov. 8, 1966.

A method is described for forming a very pure carbide by arc melting the elemental constituents, heating to above 2,000°C in vacuum, crushing, and again heating to 2,000°C in vacuum. (AEC)

**520** PREPARATION OF A FILTERABLE CO-PRECIPITATE OF PLUTONIUM AND URANIUM. Lyon, Ward L. (to U. S. Atomic Energy Commission). U. S. Patent 3,287,279. Nov. 22, 1966.

A process is described for producing a homogeneous plutonium oxide–uranium oxide fuel for a nuclear reactor. An easily filtered hydrous oxide mixture of plutonium and uranium is coprecipitated from an acidic feed solution containing plutonium and uranium in a mole concentration ratio between about 0.7 and 1.5 by the addition of ammonium hydroxide. The precipitate is washed, dried, and reduced in a hydrogen atmosphere, then mixed and blended with reactor grade uranium oxide to adjust the plutonium-uranium ratio to the desired value. (AEC)

## *Properties Evaluations*

*Refer also to abstract 477.*

**521** (NP–16348(Pt.1)) INVESTIGATIONS OF FINE FUEL IN AUTOCLAVES. PART I. THORIUM OXIDE. Boekschoten, H. J. C. (Keuring van Electrotechnische Materialen, N. V., Arnhem (Netherlands)). May 5, 1966. 34p. (Ch-E/Int.R.–38/66). Dep. mn.

Studies were made of the flow properties, sedimentation, and caking of $ThO_2$ suspensions for the Kema Suspension Test Reactor. The following conclusions were made: agglomeration is important in the range between low and high shear stresses; soft cake is formed at low temperatures and high concentrations and depends on the kind of suspension, but is nearly absent in acid medium. (D.L.C.)

**522** (AEC-tr–6808) HARDENING OF SAP/$Al_2O_3$ ALLOYS AT LOW TEMPERATURES. Guyot, P.; Debeir, R. Translated from Acta Met., 14: 42-55(1966). 26p. Dep. mn. JCL $2.60 fs, $0.98 mf.

The hardening of SAP has been studied at low temperatures. The analysis of tensile curves, the determination of activation energy and of activation volumes show that the mechanism of deformation is a thermally activated intersection of the dislocations in the Al matrix. The density of dislocations is high, being of the order of $10^{11}$/$cm^2$; owing to the indirect action of the alumina particles it increases rapidly vs the plastic deformation, thus leading to high strain hardenings. This hardening at high temperatures is not due to any atomic impurities. (auth)

**523** SUPERCONDUCTING CRITICAL TEMPERATURES OF NONSTOICHIOMETRIC TRANSITION METAL CARBIDES AND NITRIDES. Toth, L. E.; Wang, C. P.; Yen, C. M. (Univ. of Minnesota, Minneapolis). Acta Met., 14: 1403-8(Nov. 1966).

Superconducting critical temperatures were studied in the $TiN_{1-x}$, $VN_{1-x}$, YN, $VC_{1-x}$, and Ta–W–C systems. The data are reviewed together with other superconducting measurements for monocarbides and mononitrides of transition metals from the III to VI groups of the Periodic Table. Data for both stoichiometric and nonstoichiometric phases are correlated with the electron concentration. This correlation is found to be consistent with theoretical band structures and experimental data on the magnetic susceptibilities, Hall coefficients and thermoelectric powers. The variation of the $T_c$'s of nonstoichiometric phases is discussed in terms of Denker's theoretical model. (auth)

**524** DISPERSION-STRENGTHENED ALUMINUM OXIDE. McHugh, C. O.; Whalen, T. J.; Humenik, M. Jr. (Ford Motor Co., Dearborn, Mich.). J. Amer. Ceram. Soc., 49: 486-91(Sept. 21, 1966).

Finely divided Mo particles were dispersed in $Al_2O_3$ to serve as inclusions for the inhibition of grain growth and secondary recrystallization during sintering. Conventional powder metallurgy techniques were used to fabricate compacts of $Al_2O_3$ containing up to 16 vol % Mo. Three methods for developing a uniform dispersion of Mo particles in $Al_2O_3$ are compared on the basis of the resulting microstrucures. Specimens sintered in vacuum had densities approaching 98% of theoretical density with an average grain size of 2μ or less with no evidence of secondary recrystallization. The grain refinement is reflected in transverse rupture strength data with average strengths exceeding 80 kpsi and maximum strengths exceeding 100 kpsi. (auth)

**525** LATTICE AND GRAIN-BOUNDARY DIFFUSION OF URANIUM IN $UO_2$. Yajima, S.; Furuya, H.; Hirai, T. (Tohoku Univ., Sendai). J. Nucl. Mater., 20: 162-70(Aug. 1966).

Lattice and grain-boundary diffusion of U ions in polycrystalline $UO_2$ were measured at 1900 to 2150°C, by using $^{237}U$ as a tracer and the sectioning method. The obtained penetration curve consisted of two regions. In the first region near the surface, lattice diffusion and grain-boundary diffusion made a contribution to the concentrations of diffusants. In the second region, whose penetration depth is greater than in the first region, grain-boundary diffusion was dominant, and lattice diffusion was neglibible as compared with the former. The data were analyzed using the theory for grain-boundary diffusion based on an instantaneous source model. The lattice diffusion coefficient D can be obtained by the equation: $D = 5.82 \times 10^{-5} \exp(-72{,}700/RT)$ $cm^2$/sec. The product $D' \cdot 2a$ peculiar to grain-boundary diffusion follows the equation: $D' \cdot 2a = 5.19 \times 10^{-9} \exp(-47{,}200/RT)$ $cm^3$/sec, where D' and 2a are the grain-boundary diffusion coefficient and the grain-boundary width, respectively. (auth)

**526** THE EFFECT OF ELECTRICAL CONDUCTION IN $UO_2$ ON THE MEASUREMENT OF ITS HIGH TEMPERATURE THERMAL CONDUCTIVITY AS DETERMINED BY RADIAL FLOW TECHNIQUES. Ainscough, J. B. (United Kingdom Atomic Energy Authority, Springfields, Eng.). J. Nucl. Mater., 20: 184-92(Aug. 1966). (TRG-Report–1051).

In direct determinations of the high temperature thermal conductivity of dense sintered polycrystalline $UO_2$ an increase in conductivity at high temperatures (>1800°C) was found. This increase appears to be most marked where a radial flow technique was used in the determination and it is suggested that some of this effect may be due to heat generation in the oxide since at high temperatures its electrical conductivity is appreciable. If no allowance is made for this and if it is assumed subsequently that all the heat dissipated by the specimen is generated in the wire, the calculated thermal conductivity will be in error. A computer program was written to assess the possible magnitude of this effect and the results of calculations made with it are described. (auth)

## *Structure and Phase Studies*

*Refer also to abstracts 456 and 525.*

**527** INVESTIGATION OF BINARY URANIUM OXIDES AND RARE EARTH ELEMENTS. Koshcheev, G. G.; Kovba, L. M.; Zhelankin, A. V. Vestn. Moskov. Univ., Ser. II: Khim., No. 6, 53-6(Nov.-Dec. 1965). (In Russian).

In $R_2O_3$–$U_3O_8$ systems fluorite-like phases are formed, in which the valence state of uranium is assumed to be the same as in $U_3O_8$ itself. This problem was further studied by examining the formation of such fluorite-like phases in the $R_2O_3$–$U_3O_8$–$O_2$ systems, in which R designates lanthanum, samarium, dysprosium, or ytterbium. The double oxide was prepared by simultaneous precipitation from a solution of the nitrates with ammonium hydroxide, followed

by calcination at 1200°C. The hexavalent uranium concentration of the compound was determined by coulometric titration, identifying the phases by x-ray diffraction. It was found that the degree of oxidation of uranium depends on the R:U ratio; the valence of uranium is 6 at R:U ratio of 2:1. Thus, the presence of rare earths appears to increase the stability of hexavalent uranium at elevated temperatures. In spite of the similarity of the radii of the rare earth elements and of the type of coordination, the solubility in $U_3O_8$ was very low, amounting to less than 1.5 mole % of $RO_{1.5}$. (TTT)

**528** δ-$U_3O_8$: A HIGH TEMPERATURE MODIFICATION. PART II. SINGLE CRYSTAL STUDIES. Amirthalingam, V. (Atomic Energy Establishment, Trombay, India). J. Nucl. Mater., 20: 193-4(Aug. 1966).

Single crystals of δ-$U_3O_8$ were studied by rotation and Weissenberg techniques. The cell dimensions determined are a = 6.70; b = 4.14; c = 8.53 Å; z = 2 ($U_2O_5$ + ⅓ O); space group Ccc2 or Iba2. The computed x-ray density is 7.89 g/cm³. (auth)

**529** ELECTRIC CONDUCTIVITY AND THERMOELECTRIC POWER OF URANIUM OXIDIZED AT $10^{-3}$ Torr AND 500 TO 800 DEG C. Steeb, S.; Knoll, W. (Max-Planck-Institut fuer Metallforschung, Stuttgart). J. Nucl. Mater., 20: 133-40(Aug. 1966). (In German).

U films, produced by evaporation in high vacuum, were treated at 500 to 800°C with $O_2$ ($10^{-3}$ torr) and at the same time both the electrical conductivity and thermoelectric power were measured. The band model is used for the interpretation of the resistance-vs-time curves. Valence and conduction bands are 3 ev apart, while the acceptor and donor levels are 0.44 or 0.51 ev distant from the band below or above. These values were obtained from the measured temperature-resistance curves. The measurement of thermoelectric power showed that U oxides exhibit p-type conductivity at small O contents and n-type conductivity at larger O contents. The absolute values of thermoelectric power against pt are given, as well as its dependence on the O content. The results concerning electrical conductivity and thermo-electric power, obtained by interruption of the gas flow, are discussed. In accordance with structure investigations of thin films it is shown that at 650°C $U_3O_8$ is formed as a single phase. The values of specific electrical resistivity, thermoelectric force against Pt, and the activation energy of various U oxides are summarized. (auth)

**530** ON INFLUENCE OF CARBON CONTENT ON THE COBALT PHASE CONTAINED IN WC BASE CEMENTED CARBIDES. Kubota, Haruo; Ishida, Ryuichi; Hara, Akio. Sumitomo Elec. Tech. Rev., No. 6, 87-93 (July 1965).

The Co phase contained in WC-base cemented carbides was studied in relation to the C content of the cemented carbide within the range in which no eta and no free C phase appeared. And the influence of the change of Co phase on the mechanical properties was examined. The Co phase is not pure but is a Co–W–C alloy which contains sometimes more than 10% W. (auth)

## *Radiation Effects*

*Refer also to abstracts 447, 502, and 1155.*

**531** (BNWL-237) HIGH TEMPERATURE RADIATION DAMAGE TO GRAPHITE. PART II. RADIATION DAMAGE IN GRAPHITE. Meers, J. T.; Doar, J. F.; Yoshikawa, H. H. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab. Union Carbide Corp., Parma, Ohio. Carbon Products Div.). May 1966. Contract AT(45-1)-1603. 62p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

All of the post irradiation test data through June 1, 1965, for the samples described in Part I of this report are tabulated by sample set. From this mass of data, selected cases of interest have been chosen for discussion of each of the properties which were measured. Lengths and coefficients of thermal expansion were determined by Battelle-Northwest Laboratory; the remainder of the properties discussed were measured by the Research Laboratory staff of the Carbon Products Division of Union Carbide Corporation. (auth)

**532** TRANSMISSION ELECTRON MICROSCOPE STUDIES OF NEUTRON IRRADIATED BERYLLIUM OXIDE. Rau, R. C. (General Electric Co., Cincinnati). J. Nucl. Mater., 20: 141-52(Aug. 1966).

Defect clusters produced in BeO by neutron irradiation were examined by transmission electron microscopy of thin chips. Specimens studied were given fast neutron dosages ranging from $5 \times 10^{19}$ to $\approx 5 \times 10^{21}$ nvt at temperatures ranging from pile ambient to 1200°C. Low temperature, low dose irradiation produces almost imperceptibly small dot clusters which enlarge with both increasing irradiation dose and temperature. In specimens irradiated at approximately 650°C, the dot clusters begin to show evidence of alignment parallel to the BeO basal plane and irradiation at temperatures above ≈800°C produces resolvable loops in the basal plane which are believed to be planar groups of interstitials or vacancies. Because of the predominant prismatic cleavage of BeO, these loops are usually observed in cross section and appear as lines perpendicular to the crystallographic c-axis. A few instances of loops oriented in prism planes were also seen in BeO irradiated at high temperatures. Post-irradiation annealing of BeO containing basal plane defects produced a relatively defect-free structure similar to that of the unirradiated state. (auth)

**533** ANNEALING OF IRRADIATION DAMAGE IN GRAPHITE. Kelly, B. T.; Martin, W. H.; Price, A. M.; Dolby, P.; Smith, K. (United Kingdom Atomic Energy Authority, Culcheth, Eng.). J. Nucl. Mater., 20: 195-209 (Aug. 1966).

A study was made of thermal annealing of irradiation damage in graphite after fast neutron bombardment at 150 to 350°C. The study was made on pyrolytic graphite and on reactor graphite. Dimensional changes, thermal conductivity, and thermal expansion coefficients were investigated on both materials and electrical resistivity and Young's modulus on the reactor graphite. Measurements of crystal dimensional changes are in reasonable agreement with those for the pyrolytic graphite. It is found that the crystal dimensional changes induced by irradiation above 300°C are essentially nonannealable, although all other physical properties recover their unirradiated values. The results show that there is a transition from recoverable to nonrecoverable dimensional changes in this temperature range and that the defects mainly responsible for dimensional changes have little effect on other properties. (J.R.D.)

**534** EJECTION OF URANIUM ATOMS FROM SINTERED $UO_2$ BY FISSION FRAGMENTS IN DIFFERENT GASES AND AT DIFFERENT GAS PRESSURES. Nilsson, G. (Aktiebolaget Atomenergi, Stockholm). J. Nucl. Mater., 20: 215-30(Aug. 1966).

The emission of U atoms from the surface of sintered discs of $UO_2$ was measured over the range $5 \times 10^{15} - 7 \times 10^{16}$ fissions/cm² in air at a pressure of about $5 \times 10^{-3}$ Torr and in air, Ar, and $N_2$ over the pressure range $10^{-5}$–760 Torr for irradiations to about $3 \times 10^{16}$ fissions/cm². The atoms emitted were collected on catcher foils and the amount collected was determined by fission counting. The number of U knock-ons ejected by a fragment was calculated. At $10^{-5}$ Torr the number of U atoms emitted per escaping fission fragment was found to be about 9, which is of the same order of magnitude as the number of U knock-ons ejected by a fragment. At high $O_2$ pressures the emission of U atoms increases considerably. The mean range in $UO_2$ of fission products of mass 140 was found to be 7.37 ± 0.05 mg/cm² by direct gamma spectrometric determination of the fraction of $^{140}La$ escaping from the surface of the discs. (auth)

# PHYSICS (GENERAL)

## Astrophysics

*Refer also to abstracts 633, 636, 662, 693, 694, 781, 797, 855, and 856.*

**535** (AD-632171) RESEARCHES IN SOLAR PHYSICS DURING 1965. Jensen, Eberhalt (Oslo Univ. (Norway). Dept. of Astrophysics). Jan. 31, 1966. Contract AF61(052)-743. 39p. (AFCRL-65-258). CFSTI $3.60 cy, $0.50 mn.

A report on work at Oslo Solar Observatory during 1965 on burst phenomena, solar spectroscopy, and sunspot structure is presented. (auth)

**536** (N-66-21440) SURVEY OF EXTRATERRESTRIAL NON-SOLAR X-RADIATION BY ROCKET BORNE INSTRUMENTS. Final Report. Gursky, H.; Giacconi, R.; Waters, J. R. (American Science and Engineering, Inc., Cambridge, Mass.). 1965. Contract NASw-898. 214p. (NASA-CR-71522; ASE-2017). CFSTI $6.00 cy, $1.25 mn.

The design, integration, and construction of two fully instrumented payloads to perform observations of x rays originating from outside the solar system are reported. Also reported are the reduction and analysis of the data obtained during the Aerobee rocket flight of these payloads. A survey was made of the directional intensity on non-solar cosmic x rays, a rough survey was obtained of their spectral composition between 10 Å and 0.1 Å, thermal and non-thermal components where distinguished, and regions of strong intensity were correlated with optical and radio objects of special interest. Appendices of reports published during this study are included, and give results of the rocket flights, as well as descriptions of the instrumentation. (STAR)

**537** (N-66-23824) ROCKET STUDY OF STELLAR X-RAY EMISSIONS. Final Report. Fisher, Philip C. (Lockheed Missiles and Space Co., Palo Alto, Calif. Research Labs.). Jan. 17, 1966. Contract NASw-909. 88p. (NASA-CR-74276; LMSC/M-23-66-1). CFSTI $3.00 cy, $0.75 mn.

The experiment was directed toward discovering, locating, and obtaining spectral information for stellar x-ray sources at low galactic latitudes. A fundamental assumption was that the brightest x-ray sources would be found to be of galactic origin and would be clustered near the galactic equator. This assumption was proven correct. Appended are three publications of reduced data from two previous rocket flights, and two articles containing the results of the first of two ACS rocket flights. A brief and preliminary estimate of the results of the second ACS rocket flight is also included. (STAR)

**538** (NYO-3164-2) SUMMER SEMINAR ON RELATIVITY AND ASTROPHYSICS [HELD AT CORNELL UNIVERSITY, ITHACA, NEW YORK], 1965. (Selected Lectures Only). Final Report. (American Mathematical Society, Providence, R. I.). Contract AT(30-1)-3164. 475p. Dep. mn. CFSTI $7.75 cy, $2.00 mn.

Fifteen selected lectures from the conference are presented. Separate abstracts were prepared for fourteen of the lectures. One lecture which appeared in Phys. Rev. (141: 1232-41 Jan. (1966)) was previously abstracted in NSA 20: 11434. (W.D.M.)

*For abstracts of individual lectures see: 539–546, 633, and 855–859.*

**539** (NYO-3164-2, Lect. 1) LECTURES ON QUASI-STELLAR OBJECTS. Schmidt, Maarten (Carnegie Institution of Washington, D. C.). 22p.

Observations and the nature of quasi-stellar objects are discussed. It is assumed that the quasi-stellar radio sources are very distant extragalactic objects, although some recent reasons for doubting this are mentioned. (W.D.M.)

**540** (NYO-3164-2, Lect. 4) A UNIFIED APPROACH TO COSMOLOGY. Layzer, David (Harvard Coll. Observatory, Cambridge, Mass.). 52p.

It is assumed that the defining properties of the universe have the status of natural laws. This approach leads toward the simplest hypotheses which are especially vulnerable to observational disproof. Some consequences of what appears to be the simplest cosmological postulates that are consistent with currently accepted physical laws are developed. (W.D.M.)

**541** (NYO-3164-2, Lect. 5) STRUCTURE AND DYNAMICS OF GALAXIES. Woltjer, L. (Columbia Univ., New York). 82p.

Since stars make up a large fraction of the total mass of most galaxies and since in some ways the dynamics of a stellar system are simpler than those of a gaseous one, a theoretical framework for the description of stellar systems is developed. Then the observed features of galaxies and the role of gases are considered. (W.D.M.)

**542** (NYO-3164-2, Lect. 6) RADIOGALAXIES. Burbidge, E. Margaret (California Univ., La Jolla, San Diego). 16p.

A brief historical account of the radio galaxies is given and the radio structure and time scales for radio emission is reviewed. Identifications of radio sources and the mechanism of radio emission are discussed. Detailed structure of radio galaxies is considered with M82, NGC 1275, and NGC 1068 taken as specific examples. (W.D.M.)

**543** (NYO-3164-2, Lect. 8) THE DYNAMICS OF STAR CLUSTERS. King, Ivan R. (California Univ., Berkeley). 18p.

The dynamics of globular clusters containing on the order of $10^5$ stars are considered. The systems discussed are spherically symmetric with random motion and no net rotation. The effects of gases are neglected. It is indicated how open clusters and elliptical galaxies differ from the globular clusters. (W.D.M.)

**544** (NYO-3164-2, Lect. 9) APPLICATIONS OF THE THIRD INTEGRAL IN THE GALAXY. Contopoulos, George (National Aeronautics and Space Administration, New York. Goddard Inst. for Space Studies). 27p.

The application of the third integral in explaining the forms of the galactic orbits in meridian planes following the stars in their motions is discussed, along with another application which refers to the plane galactic orbits if the galactic potential is not exactly symmetric, but has a plane of symmetry. Other applications of the third integral considered include the explanation of the three-axial form of the velocity ellipsoid and the construction of galactic models. (W.D.M.)

**545** (NYO-3164-2, Lect. 10) FRAGMENTATION. Hunter, C. (Massachusetts Inst. of Tech., Cambridge). 47p.

In stellar evolution it is supposed that a large mass of diffuse gas is somehow brought to a state in which it is unstable with respect to its own self-gravitational attraction. The gravitational instability is such that the cloud of diffuse matter starts to collapse in on itself. Because the critical mass of the unstable cloud is considerably greater than that of the largest conventional star, it must fragment in some way rather than collapse as a single entity. The likely workings of this process of fragmentation, when it arises, and what aids and inhibits it are discussed. (W.D.M.)

**546** (NYO-3164-2, Lect. 11) STELLAR STRUCTURE LEADING UP TO WHITE DWARFS AND NEUTRON STARS. Salpeter, E. E. (American Mathematical Society, Providence, R. I.). 75p.

The static (or quasi-static) aspects of stellar structure and evolution are dealt with. Topics covered include observations, stellar structure theory, radiation pressure and degeneracy, white dwarfs, neutron stars, and supernova. (W.D.M.)

**547** INVESTIGATING THE EVOLUTION OF METEORITIC MATTER FROM THE EFFECTS OF THE NUCLEAR REACTIONS INDUCED BY COSMIC RAYS. Lavrukhina, A. K. (Vernadskii Inst. of Geochemistry and Analytical Chemistry, Academy of Sciences, USSR). Izv. Akad. Nauk SSSR, Ser. Geol., No. 12, 3-11(1965). (In Russian).

Current theories on the origin, age, and composition of meteorites are evaluated against a background of new data obtained from orbital studies, geochemical analysis, and radioactive methods of age determination. Three model theories of meteorite formation and evolution are discussed: (1) the Urey model in which achondrites and iron meteorites are believed to have been formed in primary bodies of lunar dimensions, while chondrites were formed in secondary bodies of asteroidal size from the ducts of disintegration of the primary bodies; (2) the model, attributed to Anders and Ringwood, involving the differentiation of matter from a parent body; and (3) the model, attributed to Vinogradov and Wood, in which chondrules are believed to have developed from a protoplanetary dust cloud. Examination of age data obtained by methods based on the decay of all natural radioactive elements ($^{238}U$, $^{187}Re$, $^{40}K$, $^{87}Rb$) indicates that meteoritic matter solidified some 4.5 million years ago. In the light of the hypothesized common process of formation of all bodies of the solar system from the protoplanetary cloud, this determination of the time of solidification of the matter of the solar system is considered to be a major advance in meteoritics. Data now available indicate three possible processes whereby meteorites developed into separate astronomical bodies: (1) Larger bodies disintegrated into progressively smaller meteoritic bodies. (2) Meteorites falling onto the earth were actually formed on the moon when other meteorites originating in the asteroid belt collided with the earth's satellite. In this process the surface layer of the moon provided the matter found in so-called hypersthenic meteorites, while matter from the lunar interior entered into the composition of so-called bronzite meteorites. (3) Hypersthenic meteorites originated in the collision and subsequent disintegration of large asteroids some 500,000,000 years ago. It is concluded, however, that all available data on bronzite meteorites attest to their formation about 5,000,000 years ago in disintegration of a single primary body whose matter did not undergo the changes evident in hypersthenic meteorites. This is in accord with the determination of a higher content of metallic iron and lower content of oxidized iron in bronzites than in hypersthenics. (ATD)

**548** LITHIUM ABUNDANCE AND THE STRUCTURE OF THE OUTER CONVECTION ZONE IN STARS SIMILAR TO THE SUN. Boehm, K.-H. (Univ., Heidelberg). Z. Naturforsch., 21a: 1107-15(July 1966). (In German).

The observations of lithium abundance and the isotope ratio $^6Li/^7Li$ in stars are briefly reviewed and some simple conclusions are drawn. It is emphasized that a slow (timescale $\approx 10^9$ years) mixing process in main-sequence F and G stars is necessary to account for the observations. The present state of the theory of convective overshooting is reviewed in this context. Two new models of the outer solar convection zone are presented. The temperature at their lower boundaries are $2.04 \times 10^{6\circ}K$ and $2.27 \times 10^{6\circ}K$, showing that only a rather small convective overshoot may be sufficient for mixing the matter in the convection zone with the layers, in which $^7Li$ is burnt. The models differ from earlier ones, because (when calculating the mean stratification) the condition that the mixing length can nowhere be larger than the distance from the nearest boundary of the convection zone is taken into account. It is shown that this approach also leads to a slight change of the numerical factors in the formulae usually used. (auth)

**549** NEUTRON EXPOSURE AGES OF METEORITES. Fireman, E. L. (Smithsonian Astrophysical Observatory, Cambridge, Mass. Harvard Coll. Observatory, Cambridge, Mass.). Z. Naturforsch., 21a: 1138-46(July 1966).

$^{60}Co$ and $^{39}Ar$ were measured in a number of recently fallen meteorites. From these data the amount of shielding surrounding the samples in space was estimated. In the carbonaceous chondrite, Murray, the $^{60}Co$ activity was very large compared to the $^{60}Co$ activities in the other chondrites even though the $^{39}Ar$ activities were almost identical. In the iron meteorites there was an inverse relationship between the $^{60}Co$ and $^{39}Ar$ activities; shielding material increased the $^{60}Co$ activity and decreased the $^{39}Ar$ activity. In the cases of Abee and Bruderheim, neutron exposure ages were obtained from the $^{80}Kr/^{60}Co$, $^{82}Kr/^{60}Co$, and $^{128}Xe/^{60}Co$ ratios because the $^{60}Co$ was measured in large samples from the interior of the same fragment in which krypton, xenon, bromine, and iodine had previously been measured. The neutron exposure ages were approximately an order of magnitude larger than the spallation exposure ages. The order-of-magnitude differences in the exposure ages could be attributed to space erosion or to an ancient neutron irradiation. (auth)

**550** MEASUREMENT OF THE DIFFUSION LOSSES OF RADIOGENIC AND SPALLOGENIC RARE GASES IN STONE METEORITES. II. Hintenberger, H.; Schultz, L.; Waenke, H. (Max-Planck-Institut fuer Chemie, Mainz). Z. Naturforsch., 21a: 1147-59(July 1966). (In German).

Rare gas measurements (helium and neon) were carried out on single mineral components of 10 bronzite-chondrites, 10 hypersthene-chondrites, and 1 amphoterite. Diffusion losses of $^3He$ were detected in pyroxene on most meteorites studied. The helium content of olivine was found to be far less affected by diffusion compared to pyroxene. A loss of spallogenic helium is always connected with a loss of radiogenic helium. For most of the bronzite-chondrites the loss of radiogenic helium occurred only during the time of cosmic-ray exposure due to a more intensive heating caused by orbits closer to the sun. Bronzite-chondrites containing high amounts of primordial gases showed equal relative losses of spallogenic and radiogenic helium each. The reason for this unexpected result is not clear, but it might be that it results from a grain-size-effect and perhaps also holds true for all other meteorites as far as diffusion loss in space due to solar heating is concerned. Many of hypersthene-chondrites suffered inside their parent bodies considerable losses of radiogenic helium before their exposure to the cosmic rays. From the radiogenic helium content in pyroxene an age of $560 \cdot 10^6$ years was calculated for five of these meteorites. It could be proved that the highly varying ratio of $^3He/^{21}Ne$ in chondrites cannot be attributed to diffusion losses. Variations up to a factor of 4 were confirmed. The content of $^3He$ in the metal phase of most meteorites investigated was found to be too low up to a factor of 2. A tritium loss in space is suggested as explanation of these deficiencies. (auth)

**551** COMPRESSION WAVES IN AN ISOTHERMAL ATMOSPHERE WITH VERTICAL MAGNETIC FIELD. Luest, R.; Scholer, M. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Z. Naturforsch., 21a: 1098-1106(July 1966). (In German).

The propagation of waves in the solar atmosphere is investigated with respect to the problem of the chromospheric spiculae and of the heating of the solar chromosphere and corona. In particular the influence of external magnetic fields is considered. Waves of finite amplitudes are numerically calculated by solving the time-dependent magnetohydrodynamic equation for two spatial dimensions by assuming axial symmetry. For the case without a magnetic field the comparison between one dimensional and two dimensional treatment shows the strong influence of the radial propagation on the steepening of waves in the vertical di-

rection. In the presence of a magnetic field it is shown that the propagation is strongly guided along the lines of force. The steepening of the waves along the field is much larger as compared to the case where no field is present. (auth)

**552** RAYLEIGH PARTICLES ($a < 10^{-5}$ cm) IN INTERPLANETARY SPACE. Elsaesser, Hans; Schmidt, Thomas (Landessternwarte, Heidelberg). Z. Naturforsch., 21a: 1116-22(July 1966). (In German).

The question of submicron particles in interplanetary space is discussed in some detail. On the assumption that the polarization of the zodiacal light is due to scattering of sunlight by submicron particles their spatial density is derived. The investigation of the forces exerted on those particles by the radiation pressure of sunlight and by interaction with the particles and magnetic fields of the solar wind shows that the "lifetime" of submicron particles in interplanetary space is probably less than $10^3$ years. Therefore it seems doubtful that they can exist in considerable numbers. (auth)

**553** MODEL FOR VARIABLE EXTRAGALACTIC RADIO SOURCES. Van Der Laan, H. (National Radio Astronomy Observatory, Charlottesville, Va.). Nature, 211: 1131-3(Sept. 10, 1966).

The recently discovered temporal variations in the mm and cm radiation from a number of quasi-stellar radio sources and one Seyfert galaxy provide valuable information for radio astronomy. It was suggested that the varying components are sources of synchrotron radiation which are initially optically thick but, as they expand, become optically thin at progressively longer wavelengths. A quantitative discussion is presented of the evolving synchrotron self-absorption model. The time dependence of the radio spectrum is derived and it is shown how variations observed at one frequency may be used to predict the behavior at any other frequency. (M.O.W.)

**554** POLARIZATION CHARACTERISTICS OF TYPE IV BURSTS. I. OBSERVATIONAL RESULTS. Kai, Keizo (Tokyo Univ.). Pub. Astron. Soc. Jap., 17: 294-308(1965).

A systematic investigation of the polarization characteristics of Type-IV bursts over a wide frequency range is presented. Positional and directional characteristics are also considered. The frequencies of the 18 observed bursts ranged from 200 Mc to 9.4 Gc. A new, four-component model of dynamic spectra is proposed for Type-IV bursts. (IAA)

**555** POLARIZATION CHARACTERISTICS OF TYPE IV BURSTS. II. PHYSICAL INTERPRETATION. Kai, Keizo (Tokyo Univ.). Pub. Astron. Soc. Jap., 17: 309-36(1965).

An attempt is made to furnish a physical interpretation of Type-IV bursts which will consistently account for their polarization characteristics. Different mechanisms are suggested for the polarized and unpolarized portions of the bursts. (IAA)

**556** POLAR RAYS OF THE SOLAR CORONA OBSERVED AT THE 1965 MAY 30 ECLIPSE IN THE SOUTH PACIFIC. Saito, Kuniji (Tokyo Univ.). Pub. Astron. Soc. Jap., 17: 421-6(1965).

A study is presented of the polar rays of the solar corona, using a photograph taken at Manuae, in the Cook Islands, during the total eclipse of May 30, 1965. The variability of the polar magnetic field of the sun, expressed in terms of the behavior of the hypothetical bar magnet, is reconfirmed. (IAA)

**557** GENERATION OF MAGNETOHYDRODYNAMIC WAVES IN SUNSPOTS. Marik, M. (Eoetvoes Univ., Budapest). Soviet Astron.-AJ (Engl. Transl.), 10: 315-19(Sept.-Oct. 1966).

Translated from Astron. Zh., 43: 400-6(Mar.-Apr. 1966).

According to the Vitense model, the condition that the magnetic energy beneath a spot equals the kinetic convective energy yields the depth of the layer where the magnetic field significantly affects the convection. The emergent Alfvén-wave flux is estimated, assuming that the wave amplitude equals the convective velocity in this zone. Allowance for reflection of waves indicates that the wave amplitude remains approximately constant with height. Allowance for the magnetic field has little effect on the convective-zone model up to the critical layer; hence the mean velocity there, which governs wave generation, differs little from Vitense's value. The wave generation is computed by Kulsrud's method. Few accelerated waves are emitted beneath a spot, but the emission of retarded and Alfvén waves is the same. The values for the Alfvén-wave flux differ little from qualitative estimates, but are an order higher than the flux from ordinary active regions. The chromosphere therefore has different properties above a spot. (auth)

**558** DISINTEGRATION OF THE SOLAR CELLULAR BELT. Chertoprud, V. E. Soviet Astron.-AJ (Engl. Transl.), 10: 308-14(Sept.-Oct. 1966).

Translated from Astron. Zh., 43: 390-9(Mar.-Apr. 1966).

An explanation offered previously for cyclic solar activity, in which a cellular belt is produced in the convective layer and then decays gradually, is elaborated by a detailed analysis of how the belt decomposes into cells. Estimates based on very general assumptions confirm the mode of disintegration. The phase of successively disintegrating cellular belts might be synchronous with the periodically varying fluctuation level. (auth)

**559** RELATION BETWEEN PROTON FLARES AND THE CORONA OVER THE 11-YEAR CYCLE. Gnevyshev, M. N.; Krivskii, L. (Central Astronomical Observatory, Academy of Sciences, USSR. Astronomical Inst., Czechoslovak Academy of Sciences, Czech.). Soviet Astron.-AJ (Engl. Transl.), 10: 304-7(Sept.-Oct. 1966).

Translated from Astron. Zh., 43: 385-9(Mar.-Apr. 1966).

Over the 11-year solar cycle two maxima occur in the count of proton and chromospheric flares, as well as in the areas of sunspots, number of prominences, and in the intensity of the corona and of solar radio emission. Proton flares develop in regions of enhanced coronal brightness. During the second maximum, strong phenomena, such as cosmic-ray flares, predominate particularly. The proton flares recorded during 1954 to 1964 are catalogued. (auth)

**560** A THEORY FOR TYPE I SOLAR RADIO BURSTS. Trakhtengerts, V. Yu. (Gorkii State Univ., USSR). Soviet Astron.-AJ (Engl. Transl.), 10: 281-7 (Sept.-Oct. 1966).

Translated from Astron. Zh., 43: 356-64(Mar.-Apr. 1966).

One possible mechanism of generating type-I solar radio bursts is discussed—the interaction of coronal electrons with magnetohydrodynamic pulses of finite amplitude. Contrary to Takakura's finding, it is shown that under solar conditions the electron streams arising when particles are reflected from one or two convergent hydromagnetic wave fronts are stable with respect to plasma-wave excitation. However, a somewhat different instability can occur at a hydromagnetic wave front; it involves countercurrents of electrons accelerated to high energy in the electric field produced by charge separation at the pulse front. Whether this instability might be responsible for type-I bursts and certain other effects is discussed. (auth)

**561** EARLY EVOLUTIONARY STAGES FOR A STAR OF 30 SOLAR MASSES. Kotok, E. V. (Astronomical Council, Academy of Sciences, USSR). Soviet Astron.-AJ (Engl. Transl.), 10: 254-60(Sept.-Oct. 1966).

Translated from Astron. Zh., 43: 316-26(Mar.-Apr. 1966).

An evolutionary sequence of models is computed for a star of mass 30 $M_\odot$, including energy release by nuclear

hydrogen- and helium-burning reactions and gravitational contraction. The results are compared with those of Stothers. (auth)

**562** COLLAPSED STARS IN BINARY SYSTEMS. Guseinov, O. Kh.; Zel'dovich, Ya. B. Soviet Astron.-AJ (Engl. Transl.), 10: 251-3(Sept.-Oct. 1966).
Translated from Astron. Zh., 43: 313-15(Mar.-Apr. 1966).

A method for detecting collapsed stars which are members of spectroscopic binary systems is proposed. Several pairs are selected from among the spectroscopic binary systems with invisible companions, in which one may suppose that their components are collapsed stars. (auth)

**563** THEORY FOR THE FORMATION AND STRUCTURE OF QUASI-STELLAR RADIO SOURCES. Ozernoi, L. M. (Lebedev Inst. of Physics, Moscow). Soviet Astron.-AJ (Engl. Transl.), 10: 241-50(Sept.-Oct. 1966).
Translated from Astron. Zh., 43: 300-12(Mar.-Apr. 1966).

Several problems regarding the nature of quasars are examined qualitatively. At a certain evolutionary stage galactic nuclei and the central parts of quasars may be massive diffuse formations with strong magnetic fields and violent internal motions. This little-understood stage, with its severe departures from thermodynamic equilibrium, may well evolve into a state of random motion where equilibrium is efficiently achieved by turbulent transfer processes. A "magnetoid," a quasistationary configuration whose equilibrium is governed by a magnetic field, provides an idealized representation of many effects occurring in galactic nuclei and especially in the central parts of quasars. The gravitational energy released through secular contraction of the nucleus is the ultimate source of the intense quasar radiation. The magnetic field is an important intermediary. An exact solution is obtained for the magnetohydrodynamic equations describing stable fluid rotation along the lines of force of a toroidal magnetic field. This solution, one realization of a magnetoid, yields a characteristic time for repetition of the plasma circulation pattern in more complex magnetoid models. If quasar nuclei do experience such quasi-periodic motions a variable energy flux may result. The observed optical variability (the flux probably varies at other wavelengths also) supports the treatment suggested. Local jets and streams of matter connected with active regions may occur when quasar nuclei reach global quasiequilibrium. Although the magnetoid approach furnishes a unified explanation for the basic property of quasistellar radio sources—an intense and variable flux emitted over a fairly long period—many aspects necessarily remain speculative. (auth)

**564** GALACTIC MAGNETIC FIELD IN THE SOLAR NEIGHBORHOOD. Pronik, I. I. (Crimean Astrophysical Observatory, Academy of Sciences, USSR). Soviet Astron.-AJ (Engl. Transl.), 10: 233-40(Sept.-Oct. 1966).
Translated from Astron. Zh., 43: 291-9(Mar.-Apr. 1966).

An analysis of polarized starlight, the motions of interstellar Ca II clouds, and Milky Way photographs indicates that the galactic magnetic field is irregular in the solar neighborhood. (auth)

**565** SPECTRA OF THE RADIO SOURCES 3C 273 AND 3C 84 AT MILLIMETER AND CENTIMETER WAVELENGTHS. Kostenko, V. I.; Matveenko, L. I. (Lebedev Inst. of Physics, Moscow). Soviet Astron.-AJ (Engl. Transl.), 10: 225-7(Sept.-Oct. 1966).
Translated from Astron. Zh., 43: 280-3(Mar.-Apr. 1966).

The radio flux of 3C 84 was measured as 26 ± 7, 20 ± 0.8, and 7 ± 0.3 flux units ($10^{-26}$ W · m$^{-2}$ · cps$^{-1}$) at 8.2 mm, 3.2 cm, and 8 cm, respectively; the flux of 3C 273 was 38 ± 6 and 33.5 ± 1.2 units at 8.2 mm and 3.3 cm. The sources have flat spectra in the range 8.2 mm to 3.3 cm, within the precision of measurement. (auth)

**566** SIMULATION OF THE SOLAR WIND INTERACTION WITH COMETS. Danielsson, L. (Advanced Kinetics, Inc., Costa Mesa, Calif.). Appl. Phys. Lett., 9: 339-41(Nov. 1, 1966).

A model experiment simulating the interaction between the solar wind and comets is described. A plasma stream of $10^7$ cm/sec and $10^{13}$ protons/cm$^3$ undergoes a collisionless interaction with a cloud of $CO_2$ gas sublimated from a piece of dry ice. Time-resolved photographs show a well-defined, comet-like structure around the dry ice. An extended tail is formed by ions dragged along with the plasma stream. The ionization and acceleration processes are discussed in the light of a possible mechanism based on frozen-in magnetic fields. (auth)

**567** A SURVEY OF RADIO SOURCES AND BACKGROUND RADIATION AT 38 Mc/s. Williams, P. J. S.; Kenderdine, S.; Baldwin, J. E. Mem. Roy. Astron. Soc., 70: 53-110(1966).

The 38 Mc/s pencil beam radio telescope at the Mullard Radio Astronomy Observatory has completed a survey of the northern sky with a resolution of approximately 45′. The results are presented as (a) contour maps of brightness temperature for the range of declinations $+15° < \delta < +90°$, and (b) a list of flux densities of 1,069 discrete sources in the range $\delta \geq -10°$; for much of the area the list includes all sources with flux densities greater than the adopted minimum of $14 \times 10^{-26}$ W/m$^2$cps. The scales of brightness temperature and flux density were calibrated absolutely and are believed to be accurate to within 10%. (auth)

**568** QUASI-STELLAR OBJECTS. Schmidt, Maarten (California Inst. of Tech., Pasadena). Science, 2: No. 10, 77-83(Oct. 1966).

A general discussion is presented on the discovery, properties, observation, position, red shift, and interpretation of quasi-stellar objects. (W.D.M.)

**569** MAGNETIC FIELDS IN GALAXIES. Davies, Rodney Deane (Nuffield Radio Astronomy Labs., Cheshire, Eng.). Science, 2: No. 10, 62-70(Oct. 1966).

A general discussion is presented on the magnetic fields in galaxies, including magnetic field strengths, measurement and observation of fields, Zeeman splitting, synchrotron emission, Faraday rotation, polarization of starlight, spiral galaxies, and extragalactic radio sources. (W.D.M.)

**570** RADIO GALAXIES. Ryle, Martin; Shakeshaft, John (Cambridge Univ., Eng.). Science, 2: No. 10, 56-61(Oct. 1966).

A general discussion is presented on the discovery, physical processes, and observational techniques of radio galaxies. Intense radio emission from galaxies may be due to large scale explosions in the galactic nuclei. Surveys of these objects have penetrated back in time to the period when galaxies were initially being formed. (W.D.M.)

**571** INTERSTELLAR MOLECULE FORMATION. Stecher, Theodore P.; Williams, David A. (Goddard Space Flight Center, Greenbelt, Md.). Astrophys. J., 146: 88-103(Oct. 1966).

The formation of interstellar molecules is shown to be the result of chemical-exchange reactions between atoms of the interstellar gas and atoms chemically bound to interstellar grains. It is first shown that molecular formation by physical adsorption of the constituents on the grain with a subsequent three-body reaction is of no consequence for graphite grains and Platt particles. Previous investigation has shown that physical adsorption is inoperative as a formation mechanism on ice grains. The theory of chemical exchange is shown to apply to all types of grains and is then illustrated with graphite flakes. Production rates are given for $H_2$, CH, OH, NH, CN, CO, and $N_2$ as functions of temperature and pressure. Destruction of the molecules is due to photodissociation by starlight and also by other chemical-exchange reactions. The varying conditions in the

interstellar medium are considered. No molecules are formed when the gas is cold and quiescent. With the higher temperatures of cloud–cloud collisions, $H_2$ is formed, and it is shown that a minimum of ¾ of all interstellar hydrogen atoms are in $H_2$ molecules. CH + $CH^+$, OH, and CN are produced by chemical exchange in the observed amount when graphite grains are driven at supersonic speeds through the gas by radiation pressure near early-type stars. The process predicts the formation of $H_2$, CO, NH, and $N_2$ from graphite flakes and possibly Platt particles. (auth)

**572** IONIZED HYDROGEN IN THE PLANE OF THE GALAXY. Ellis, G. R. A.; Hamilton, P. A. (Univ. of Tasmania, Australia). Astrophys. J., 146: 78-87(Oct. 1966).

Brightness profiles of the galactic radiation observed at 2.1, 4.7, 9.6, and 19.7 Mc/s for declination –37° were analyzed. It is shown that the change in the shape of the profiles with frequency may be explained by absorption of the radiation by ionized hydrogen in the plane of the Galaxy. The emission measure is calculated as a function of galactic latitude and is found to vary from 8.1 to 165 $cm^{-6}$ $pc^{-1}$ between latitudes –60° and –5° near longitude 000°. Along a line of sight near the galactic pole the integrated emission from within the disk is found to be approximately 0.1 of that coming from outside the disk. (auth)

**573** THE CORRELATION OF COLORS WITH REDSHIFTS FOR QSS LEADING TO A SMOOTHED MEAN ENERGY DISTRIBUTION AND NEW VALUES FOR THE K CORRECTION. Sandage, Allan (Carnegie Institution of Washington, D. C. California Inst. of Tech., Pasadena). Astrophys. J., 146: 13-24(Oct. 1966).

Following earlier work by McCrea, Kardashev and Komberg, and Barnes, the colors of forty-three quasi-stellar radio sources (QSS) are found to correlate statistically with redshift. The empirical functions B — V = f(z) and U — B = g(z) permit an energy distribution function F(λ) to be derived such that the redshifting of this distribution through the U, B, and V measuring bands reproduces the correlations. This function is the monochromatic flux distribution smoothed by the broad bands of the measuring system. Relative to the distribution $F(\lambda) \propto \lambda^{-1}$, a depression exists near $\lambda_0 = 2100$ Å and a peak occurs near $\lambda_0 = 2800$ Å. These features produce the statistical color change with redshift. The K-terms to be applied to measured magnitudes for the effects of redshift are relatively small but the color corrections, $K_U - K_B$ and $K_B - K_V$, vary systematically with $\Delta\lambda/\lambda_0$ as required. The redshift varies across the U–B′ and B–V diagrams in a regular fashion–a circumstance which permits statistical predictions of the redshift using U–B and B–V balues alone. Previously unpublished two-color photoelectric measurements for twenty-two QSS candidates are given. (auth)

**574** LIFETIMES OF EXTRAGALACTIC RADIO SOURCES. Schmidt, Maarten (Carnegie Institution of Washington, D. C. California Inst. of Tech., Pasadena). Astrophys. J., 146: 7-12(Oct. 1966).

Statistical data on the space density of bright elliptical galaxies, radio galaxies, clusters of galaxies, and quasi-stellar radio sources are assembled and discussed. Since all galaxies identified with strong radio sources are intrinsically bright elliptical galaxies, there will exist a relation between their space densities and their ages. If the ellipticals are $10^{10}$ years old, then the data suggest a total harmonic-mean lifetime for the radio-galaxy stage of about $10^9$ years. A distribution of lifetimes such that the strongest sources live for around $10^6$ years and the weaker ones for several billion years would be possible. Rather more speculative considerations about the relation between quasi-stellar radio sources and radio galaxies suggest that the quasi-stellar sources may have a harmonic-mean lifetime of around $10^6$ or $10^7$ years. (auth)

**575** AGE-HELIUM CONTENT CORRELATIONS FOR TWO LOW-MASS FIELD BINARY SYSTEMS. Faulkner, John (California Inst. of Tech., Pasadena); Iben, Icko Jr.; Wilson, Olin C. Astrophys. J., 146: 271-4(Oct. 1966).

It is shown that knowledge of a well-determined mass for a star ascending the subgiant branch would provide an important test of theories of stellar evolution. Recently determined masses for the systems ADS 755 and ADS 11479 suggest that the component stars formed from material that was richer in helium than would be thought appropriate to the relevant period of formation. In particular, the assumption that these stars are as old as the Galaxy itself implies initial helium contents ≳30 percent in agreement with a recently proposed theory of the evolution of Population-II stars. (auth)

**576** RADIATIVE ENERGY LOSS FROM THE SOLAR CHROMOSPHERE AND CORONA. Athay, R. Grant (High Altitude Observatory, Boulder, Colo. Max-Planck-Institut fuer Extraterrestrische Physik, Munich). Astrophys. J., 146: 223-40(Oct. 1966).

Quantitative estimates of the rate of energy loss from the solar chromosphere and corona by radiative processes are considered in the hope that these estimates will aid in identifying the mechanical energy input mechanism. Estimated rates of energy loss are derived partially from observational data and partially from a model atmosphere. A new theoretical basis for estimating the energy loss is derived. It is shown that Osterbrock's estimate is probably too high by about an order of magnitude. The rate of energy loss per cubic centimeter is found to decrease with height, whereas the rate per gram first increases with height and then remains constant and the rate per gram of positive ions is essentially constant at all heights. If it is assumed that the available mechanical energy can be represented by the kinetic energy of photospheric macroscopic motions whose rms velocity is 1 km/sec, a characteristic time for the conversion of mechanical energy to radiant energy is about 600 sec. (auth)

**577** LINE SPLITTING OF PLASMA RADIATION AND SOLAR RADIO OUTBURSTS. Tidman, D. A. (Univ. of Maryland, College Park); Birmingham, T. J.; Stainer, H. M. Astrophys. J., 146: 207-22(Oct. 1966).

The emission of radiation at frequencies near $\omega_e$ and $2\omega_e$ from a plasma can become greatly enhanced if a flux of suprathermal electrons coexists with the thermal plasma. The effect of a weak magnetic field in the plasma on this emission is calculated. For some anisotropic distributions of suprathermal electrons, the magnetic field gives rise to a splitting of the plasma lines by an amount $\Omega^2/2\omega_e$ for the fundamental and an amount twice this value for the second harmonic. This gives a plausible explanation of the observed line splitting for a Type-II solar outburst and also therefore an indirect determination of coronal magnetic fields at the source of emission. The splitting mechanism is similar to that earlier suggested by Sturrock. However, a detailed calculation shows that anisotropic distributions of suprathermal electrons are necessary to produce a line splitting, and that Landau damping controls the energy density of the radiating plasma oscillations in all but very small sources. The intensity profiles of the emission lines would also give information on the type of suprathermal electron distributions from which the emission originates. (auth)

**578** Be STARS IN THE REGION OF h AND CHI PERSEI. Schild, Rudolph E. (Univ. of Chicago). Astrophys. J., 146: 142-51(Oct. 1966).

New spectrograms at classification dispersion for the region of h and χ Persei, a region of the sky known to be rich in Be stars, are discussed. On the basis of spectroscopic appearance, the Be stars are divided into two groups. The first group is shown to contain Be stars of varying spectroscopic appearance, including at least one shell star and two stars on the main sequence. Stars in the second group, called extreme Be stars, are found to show very little variation in spectroscopic appearance and to lie in a band centered approximately 1.5 mag. above

the main sequence. Several interpretations of the observations are considered, and the hypothesis that the extreme Be stars are rapidly rotating B stars undergoing rapid core contraction subsequent to hydrogen exhaustion in their cores is favored. The (B−V) colors of the extreme Be stars are found to have a positive excess of approximately 0.15 mag. Because no comparable deviation is observed in (U−B) colors, it is not possible to attribute this color difference to systematic temperature differences or to circumstellar reddening according to the $1/\lambda$ law. (auth)

**579** THE EVOLUTION OF AN H II REGION DURING THE FORMATION OF THE EXCITING STAR. Vandervoort, Peter O. (Univ. of Chicago). Astrophys. J., 146: 104-22 (Oct. 1966).

The dependence of the early evolution of an H II region on the finite time scale for the onset of the ionizing radiation is considered. An expression for the luminosity of the exciting star in the Lyman continuum as a function of time is derived from a phenomenological model which represents the essential features of the contraction of a massive star. The structure of the H II region is investigated in the approximation that the ionization front can be treated as a surface of discontinuity, and it is shown that in this approximation a shock precedes an ionization front of the D type into the neutral gas during the entire evolution of the H II region. This result is in contrast to the usual picture in which an ionization front of the R type advances directly into the neutral gas during the early evolution and a shock precedes a front of the D type only during the later evolution. In a more detailed analysis it is taken into account that an ionization front has a finite thickness and that it is possible to distinguish a front from an H II region only after the dimensions of the system have become comparable with the mean free path of an ionizing photon. When this is done, it is found that for a given exciting star the early evolution of an H II region is characterized by an ionization front of the R type propagating directly into the surrounding neutral gas or by an ionization front of the D type following a shock into the neutral gas according as the initial density of the neutral gas is less than or greater than a determinate critical value. (auth)

**580** ON THE HEIGHT OF FORMATION OF H-ALPHA IN THE SOLAR CHROMOSPHERE. White, O. R.; Wilson, P. R. Astrophys. J., 146: 250-6(Oct. 1966).

Several features of H$\alpha$ limb spectra, including the line emission beyond the continuum limb, were analyzed to yield information about the height of formation of H$\alpha$ in the solar chromosphere. It is concluded that de Jager's suggested value for the height of unit optical depth at the line center (5000 km) is too high. For the chromospheric features in these spectra the height of formation lies in a range from 1500 km (above a sunspot) to 2700 km. This is consistent with the limb profile analysis which yields a range from 1600 to 3000 km for a hypothetical mean chromosphere. (auth)

**581** INTERPRETATION OF LIMB INTENSITY PROFILES. Wilson, P. R. (Univ. of Colorado, Boulder). Astrophys. J., 146: 241-9(Oct. 1966).

Limb intensity profiles at the center of H$\alpha$ (i.e., intensity distribution against distance perpendicular to the limb and to the line of sight of the observer) are calculated for several simple models of the absorption coefficient at the line center. It is found that an abrupt change of gradient, which appears in many observed profiles, also appears in the calculated profiles, and in the latter this corresponds to a total tangential optical thickness of $2.6 \pm 0.6$ for a wide variety of models. Thus one relation between the parameters of the model may be obtained directly from observations. (auth)

**582** THE CHANGE OF INTENSITY, COLOR, LINE STRENGTH, AND LINE POSITION IN THE QSS 3C 446 DURING THE 1966 OUTBURST. Sandage, Allan; Westphal, J. A.; Strittmatter, P. A. (Mount Wilson Observatory, Pasadena, Calif. Palomar Observatory, Pasadena, Calif. Carnegie Institution of Washington, D. C. California Inst. of Tech., Pasadena. Univ. of California, San Diego). Astrophys. J., 146: 322-6(Oct. 1966).

During the course of routine observations of QSS's, 3C 446 was found to be abnormally bright on June 24.4 U.T. and July 12.4 U.T., 1966, showing that the object had undergone an outburst of at least 3.2 mag. sometime between Oct. 5, 1964, and June 24, 1966. To determine the extent of the change in the emission-line intensities, three well-widened spectrograms were obtained with the Hale 200-in. reflector on July 13.45, July 14.44, and July 15.40 U.T., 1966, at a dispersion of 190 Å mm. In order to obtain more precise identification and positions of the lines and to measure their intensities, the plates were microphotometered, rectified to intensities using a calibrated wedge, and analyzed by the cross-correlation filtering technique with three different filter widths. In order to test the hypothesis that the lines have remained essentially constant in absolute intensity, and that the color change is due to the increase in the equivalent width as the continuum intensity changes, the following possibilities were examined: (a) the continuum has increased in intensity by the same amount at all wavelengths and the observed change of color is due solely to the decreased contrast of the lines; and (b) the change in color is due to a combination of the effect of the lines and of a change of slope of the continuum energy distribution, again keeping the absolute strength of the lines constant. It is shown that (b) gives a self-consistent picture. (W.D.M.)

**583** A MEASUREMENT OF THE LOCATION OF THE X-RAY SOURCE SCO X-1. Gursky, H.; Giacconi, R.; Gorenstein, P.; Waters, J. R.; Oda, M.; Bradt, H.; Garmire, G.; Sreekantan, B. V. (American Science and Engineering, Inc., Cambridge, Mass. Massachusetts Inst. of Tech., Cambridge). Astrophys. J., 146: 310-16(Oct. 1966).

The location of Sco X-1, the strong x-ray source in Scorpio, was measured with a precision of about 1 arc min. The data were obtained with an instrumented payload flown on a stabilized Aerobee rocket from White Sands on March 8, 1966. The instrumentation specifications and the operating procedures are discussed. The two most probable positions of Sco X-1 are given and the possibility of an unequivocal identification of the visible and radio counterparts is pointed out. (W.D.M.)

**584** ON THE OPTICAL IDENTIFICATION OF SCO X-1. Sandage, A. R.; Osmer, P.; Giacconi, R.; (and others) (Mount Wilson Observatory, Pasadena, Calif. Palomar Observatory, Pasadena, Calif. American Science and Engineering, Inc., Cambridge, Mass. Massachusetts Inst. of Tech., Cambridge. Tokyo Univ.). Astrophys. J., 146: 316-22(Oct. 1966).

An optical search was made of the sky surrounding the new position of SCO X-1. The search was based on these results and on the working hypothesis that the image should appear starlike, be of at least 13th apparent visual magnitude, and have an ultraviolet excess. Measurements were taken by the Tokyo Observatory and by Palomar. The object found appears to have certain of the properties of an old nova even though its spectral characteristics cannot be identified with any one class of old novae. (W.D.M.)

**585** SOLAR CONTENT OF $^{13}C$. Ganiaris, N.; Bashkin, S.; Waddell, J. H. (Univ. of Arizona, Tucson. Dublin Inst. for Advanced Studies). Astrophys. J., 146: 308-10 (Oct. 1966).

The solar atmosphere at the center of the solar disk over the wavelength region between $\lambda$ 3874.00 and $\lambda$ 3874.60 was examined with the McMath solar telescope on Sept. 29, 1964. The grating was set in seventh order, the dispersion was 7.9 mm/Å, and the resolution was 600,000. An average of 68 photoelectric scans is shown. It was concluded that a good value for $^{12}C/^{13}C$ could not be deduced from the data. An estimate of $^{12}C/^{13}C \gtrsim 200$ is given. (W.D.M.)

**586** EVIDENCE FOR A POSSIBLE CORRELATION BETWEEN THE COLOR INDICES OF THE QUASI-STELLAR RADIO SOURCES AND REDSHIFT. Barnes, Ronnie C. (Indiana Univ., Bloomington). Astrophys. J., 146: 285-6(Oct. 1966).

If the U — B or B — V color index is plotted versus the redshift, z, for the twenty-one quasi-stellar radio sources whose colors and redshifts are known, evidence is found for a possible correlation between these indices and z. It is pointed out that when U B V magnitudes become available for MSH 03 — 19, MSH 14 — 21, CTD 141, 3C 454, and 3C 432 enough data should be on hand to decide whether or not a correlation between the color indices and the redshifts really exists. (W.D.M.)

**587** ON THE BINDING ENERGY OF MASSIVE STARS IN THE POST-NEWTONIAN APPROXIMATION OF GENERAL RELATIVITY. Tooper, Robert F. (Illinois Inst. of Tech., Chicago). Astrophys. J., 146: 282-5 (Oct. 1966).

A general formula in the post-Newtonian approximation for the binding energy of a spherically symmetric object is given. This is used to obtain an expression for the binding energy of a massive configuration of ideal gas and radiation in which the ratio of gas pressure to radiation pressure is constant. The exact binding energy and the binding energy in the post-Newtonian approximation can be compared on a single graph, as functions of the ratio $\alpha$ of central pressure to central rest mass energy density, and the ratio $\beta$ of gas pressure to total pressure. (W.D.M.)

**588** GENERAL RELATIVISTIC FLUID SPHERES. II. GENERAL INEQUALITIES FOR REGULAR SPHERES. Buchdahl, H. A. (Australian National Univ., Canberra). Astrophys. J., 146: 275-81(Oct. 1966).

Certain inequalities relating to regular spheres, i.e., spherically symmetric static distributions of matter whose central density and radius are finite, whose pressure and density are nowhere negative, and whose density does not increase outwards, were derived in an earlier paper. These were generally much too weak, either in the Newtonian limit, or in the limit of infinite mass concentration ($\delta = 0$), or both. In particular the upper limit established for the gravitational potential energy $\Omega$ tended to $\infty$ as $\delta \to 0$. These various defects are remedied here and some fairly sharp inequalities derived which do not become nugatory in any situation. In particular it is shown that if $\Delta$ is the boundary value of $g_{44}$ then $[(\beta + 3)^2/9(\beta^2 + 6\beta + 1)]\{1 + [4\beta/(\beta + 1)^2]\ \delta^\kappa\} \leqq \Delta \leqq 1 - [4q_c(2q_c + 3)/9(q_c + 1)^2]\ \delta^\kappa$, where q is the ratio of pressure to mean density, $\beta$ the maximum value of q, and $\kappa (\frac{1}{3} \leq \kappa \leq 4 - 2\sqrt{2})$ a certain constant which depends on $\beta$ only. The various inequalities relating to $\Delta$ and $\Omega$ are illustrated by means of specific numerical examples. (auth)

**589** LONGITUDINAL PROPER MOTION OF SUNSPOTS AND THE SOLAR ROTATION RATE. Ward, Fred (Cambridge Research Labs., Bedford, Mass.). Pure Appl. Geophys., 63: 196-204(1966/I).

The longitudinal proper motion of sunspot groups was shown to be a function of their size and relative extension in longitude. Two theories are proposed to explain these effects, which theories assume that the wind circulation of the spots and the wind field surrounding the spots are intimately connected, and dynamically interact. The retardation in the motion of large spot groups is hypothesized to be due to the effect of the latitudinal variation of the Coriolis parameter (on a rotating spherical body) and an assumed vortical circulation around the spots. The more rapid longitudinal motion of extended spot groups is suggested to be the result of the preferential occurrence and development of such groups in regions of above-average horizontal wind and wind shear. If these theories are essentially correct, the real solar rotation rate — i.e., the longitude- and time-averaged fluid motion field — should be derived from the motions of small spot groups, and is 1 to 1½% higher than the usually accepted rate which Newton and Nunn derived. (auth)

**590** AN ATTEMPT TO THE EXPLANATION AND TO THE PREDICTION OF THE ELEVEN-YEAR CYCLE OF SOLAR ACTIVITY. Nemeth, T. (Hungarian Meteorological Inst., Budapest). Pure Appl. Geophys., 63: 205-10(1966/I).

It is suggested that the reason of the subsistence of the 11 years' sunspot cycle is to be found in the conjunction of the planets. As a result of the investigations it is stated that from among the nine planets the joint tidal effect of Venus-Jupiter-Earth is a decisive factor in the variations of sunspot activity. The above three planets are every 10.4 years and 12.0 years respectively, in a close conjunction. The mean value (11.2 years) is in an almost full accordance with the average cycle-period. The fluctuations of the period of the cycle come from the fact that the planets' getting into approximately one line takes a different time within each cycle. This time delay is the cause of the stronger or weaker sunspot activity, and of the shorter or longer cycles. (auth)

**591** GRAVITATION AND THE UNIVERSE. Dicke, Robert H. (Princeton Univ., N. J.). Science, 2: No. 10, 95-100(Oct. 1966).

The structure of the universe and the role of gravitation in determining its dynamical behavior is considered. The oscillating universe model — alternately contracting to a very dense and hot state, and then expanding again — is discussed. Some of the perplexing problems inherent in this model are enumerated. (W.D.M.)

## Atomic and Molecular Physics

*Refer also to abstracts 761 and 813.*

**592** (AD-629001) RESONANCES IN THE SCATTERING OF ELECTRONS FROM ATOMS. Miller, William H. (Harvard Univ., Cambridge, Mass. Dept. of Chemistry). Feb. 16, 1966. Contract Nonr-1866(14). 20p. CFSTI $1.60 cy, $0.50 mn.

A formal procedure is developed for describing the resonances in electron-scattering from atoms caused by metastable, auto-ionizing states. It is shown that the position of a particular resonance is given exactly by the usual Rayleigh-Schrödinger perturbation series pertaining to an unperturbed discrete state embedded in an unperturbed continuum. An expression is given for the width which shows explicitly what initial state i and final state f should be used in the 'golden rule' as applied to autoionization. The formal results are applied to the lowest 1Pu resonance in He (+) — e (−) scattering; i.e., the 2s2p 1Pu metastable state of He. The resonance energy obtained is 60.28 eV above the ground state of He, and the calculated width is 0.038 eV. These results are seen to be in excellent agreement with the experimental values. (auth)

**593** (AD-631485) STUDY AND EXPERIMENTAL WORK ON ATOMIC COLLISION PROCESSES OCCURRING IN ATMOSPHERIC GASES. Technical Progress Letter No. 43. Phelps, A. V.; Kasner, W. H. (Westinghouse Research Labs., Pittsburgh, Pa.). Aug. 31, 1965. Contract AF29(601)-6729. 4p. (RM-65-6E2-113-M3). CFSTI $1.10 cy, $0.50 mn.

Progress of work in the following area is reported: temperature dependence electron–positive ion recombination in $N_2$–Ne mixtures; attachment and detachment in $CO_2$–$O_2$ mixtures and in pure water vapor; elastic and inelastic scattering cross sections for electrons in pure oxygen. (TAB)

**594** (AD-632895) EXPERIMENTAL STUDY OF TEMPERATURE DEPENDENCE ON THE CHARACTERISTIC ELECTRON ENERGY LOSSES IN ALUMINUM, TIN, MAGNESIUM, AND LEAD. Summary Technical Progress Report. Watson, Harry J.; Mitchell, Robert R. (Brown Engineering Co., Inc., Huntsville, Ala. Research Labs.). Apr. 1966. Contract Nonr-4549(00). 40p. (TN-R-196). CFSTI $2.00 cy, $0.50 mn.

The characteristic energy losses which are observed when a thin film of metal is bombarded by an energetic beam of electrons were investigated as a function of temperature from 300K to 4.2K. The metals examined are tin, aluminum, magnesium and lead. The change in plasmon energy for magnesium and tin is almost linear, but the

aluminum values increase rapidly below 77K while the values for lead decrease below 77K. The observed values are compared to those that would be expected due to a change in the free electron density caused by a thermal expansion or contraction of the sample. Values of the mean free path for plasmon production in aluminum are also presented as a function of temperature. (auth)

**595** (AD-634919) ENERGY AND ANGULAR DISTRIBUTION OF GAMMA RAYS SCATTERED IN ALUMINUM. Dardis, John G.; Scofield, Norman E. (Naval Radiological Defense Lab., San Francisco, Calif.). July 11, 1966. 40p. (USNRDL-TR-1018). CFSTI $2.00 cy, $0.50 mn.

The energy and angular distribution of plane perpendicular $^{137}Cs$ gamma rays scattered in 1 through 5 mean free paths of aluminum was measured using a NaI(Tl) spectrometer. The results are compared with distributions calculated from the method of moments and polynomial expansion. For 1 and 2 mean free paths the infinite-medium calculations for multiple scatter are considerably in excess of the experimental results at the distribution peak; otherwise, the spectrum shape is reproduced satisfactorily. For 3, 4, and 5 mean free paths the calculations are in good agreement with experiment. (auth)

**596** (AD-635618) COMPLETE NUMERICAL SOLUTION OF BOHR'S COLLECTIVE HAMILTONIAN. Kumar, Krishna; Baranger, Michel (Carnegie Inst. of Tech., Pittsburgh, Pa. Dept. of Physics). June 1966. Contract Nonr-760(15). 104p. (TR-24). CFSTI $4.00 cy, $0.75 mn.

The general form of Bohr's collective Hamiltonian for quadrupole deformations is reviewed. It contains seven largely arbitrary functions of beta and gamma, the potential energy, and six inertial functions. A thorough discussion is given of the symmetries of these seven functions and of the corresponding properties of the solutions of the Schrodinger equation. A purely numerical method involving a finite mesh is developed for solving this Schrodinger equation. The output of the calculation consists in the low-lying levels, the corresponding wave functions, and the relevant E2 and M1 static and transition moments; the latter depend on the intrinsic quadrupole moments and intrinsic gyromagnetic ratios as functions of beta and gamma. The numerical method is tested on a number of examples and is found to be sufficiently accurate for application to spherical, transition, and many deformed nuclei. (auth)

**597** (AD-636034) NEUTRAL ATOM BREMSSTRAHLUNG. Kivel, B. (Avco-Everett Research Lab., Everett, Mass.). June 1966. Contract AF29(601)-7055. 46p. (RR-247). CFSTI $2.00 cy, $0.50 mn.

Predictions are given for the bremsstrahlung absorption cross section of atomic oxygen and atomic nitrogen. The electron-atom interaction potential energy is adjusted to give agreement with the photo-absorption measurements of the negative oxygen ion. The exchange force is treated in an approximate manner following a suggestion by Slater but adjusted to take account of the dependence on the configuration of the electron wave. The difference in the exchange force for s and p-waves as well as the difference between the triplet and quintet configurations in atomic nitrogen must be preserved to obtain predictions for the bremsstrahlung which are in agreement with experiments. The atomic oxygen absorption cross section is about a factor 5 less than that of atomic nitrogen in agreement with the measurements of Taylor. The Maxwell average atomic nitrogen Bremsstrahlung absorption cross section is insensitive to temperature. The atomic nitrogen cross section deviates somewhat from the Kramers wavelength dependence becoming relatively larger in the blue. (auth)

**598** (AD-636036) BREMSSTRAHLUNG IN AIR. Kivel, B. (Avco-Everett Research Lab., Everett, Mass.). June 1966. Contract AF29(601)-7055. 20p. (RR-249). CFSTI $1.00 cy, $0.50 mn.

The partial wave analysis for bremsstrahlung and elastic scattering by molecular nitrogen is reviewed. These studies suggest that the bremsstrahlung in the field of molecular nitrogen can be estimated from the measured momentum transfer cross section. Using this approximation for the molecular components and recent calculations of bremsstrahlung in the field of atomic oxygen and nitrogen, the emissivity and intensity from neutral bremsstrahlung in high temperature air is estimated. (auth)

**599** (JINR-P-2897) REZONANSNOE RASSEYANIE SVETA NA DVUKHATOMNYKH MOLEKULAKH, NAKHODYASHCHIKHSYA VO VNESHNIKH POLYAKH. (Resonance Light Scattering by Diatomic Molecules in External Fields). Onishchuk, V. A.; Podgoretskii, M. I. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1966. 14p. Dep. mn.

The external field influence on the intensity of resonance light scattered by diatomic spinless molecules is investigated. Separate lines as well as the whole spectral region are considered. Some formulas are obtained, which may be used for the determination of the characteristics of excited molecular levels such as electric dipole moment, level width, Λ-splitting value. (tr-auth)

**600** (LA-3581) CALCULATION OF THE PHOTOELECTRIC ABSORPTION COEFFICIENT BY THE STATISTICAL METHOD. Liberman, David A.; Cherry, Ivan (Los Alamos Scientific Lab., N. Mex.). Aug. 22, 1966. Contract W-7405-eng-36. 12p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The photo-electric absorption coefficient (including transitions from one bound state to another) is calculated using the statistical (Thomas-Fermi) model. (auth)

**601** (N-66-22305) ELECTRON COLLISION CROSS SECTIONS IN METAL VAPORS. Summary Report. Nolan, J. F. (Westinghouse Research Labs., Pittsburgh, Pa.). Jan. 26, 1966. Contract NAS3-7100. 66p. (NASA-CR-54670). CFSTI $3.00 cy, $0.75 mn.

The Townsend $\alpha$ coefficient and electron drift velocity were measured in cesium-helium mixtures as a function of E/p, the ratio of electric field to total pressure, and $N_{Cs}/N_{He}$, the ratio of cesium to helium density. By comparing the measured values with the results of a numerical solution of the Boltzmann equation using assumed cesium cross sections, one obtains cross sections consistent with the measurements. A total excitation cross section for cesium having a peak value of $1.15 \times 10^{-14}$ cm$^2$ at 8 eV gives good agreement with experiment. (auth)

**602** (N-66-22363) CALCULATION OF TRANSPORT PROPERTIES OF IONIZING ATOMIC HYDROGEN. Grier, Norman T. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Apr. 1966. 87p. (NASA-TN-D-3186). CFSTI $1.25 cy, $0.75 mn.

The viscosity, thermal conductivity, electrical conductivity, binary diffusion coefficient, multicomponent diffusion coefficient, and thermal diffusion coefficient are calculated for equilibrium ionizing atomic hydrogen for temperatures from 5000 to 40,000°K at pressures from $10^{-5}$ to $10^2$ atmospheres. Rigorous first- and second-approximation equations are used throughout. The collision cross section for all the interactions are presented in tabular form. (auth)

**603** (NASA-CR-72076) INVESTIGATION OF COLLISION PROBABILITY OF ELECTRONS AND IONS WITH ALKALI METAL ATOMS. Final Report, April 22, 1964 to July 21, 1966. Bullis, R. H.; Nighan, W. L. (United Aircraft Corp., East Hartford, Conn. Research Labs.). Aug. 1966. Contract NAS3-4171. 99p.

A summary is presented of the experimental and analytical research investigations conducted at the United Aircraft Research Laboratories to determine the collision cross sections for electrons and cesium ions interacting with cesium atoms over the energy range of importance to ignited-mode thermionic converter operation. In the

first year of the contract, the momentum transfer collision probability for electrons interacting with cesium atoms was determined over an energy range from 0.2 to 0.6 ev by measuring the transport properties of the plasma existing in the positive column of a cesium arc discharge. The total cesium ion–cesium atom collision probability data previously obtained by beam techniques in a modified Ramsauer cross section experiment were analyzed to determine low-energy cesium ion mobilities, and further investigations of the low-energy cesium ion–cesium atom collision cross sections were made in an effort to extend the energy range of these measurements. In the course of these investigations, ion beams with energies as low as 0.058 eV were detected successfully. In the second year of the contract, a modified Brode-type experiment was designed and constructed in order to measure low-energy electron–cesium atom total collision cross sections. With this system electron beams with energies as low as 0.095 eV have been successfully detected. (M.O.W.)

**604** (NP–16338) THEORETICAL INVESTIGATION OF THE ABSORPTIVE PROPERTIES OF SMALL PARTICLES AND HEAVY-ATOM GASES. Report No. E-910092-7. Krascella, N. L. (United Aircraft Corp., East Hartford, Conn. Research Labs.). Sept. 1966. Contract NASw-847. 70p.

A theoretical investigation was conducted to determine the spectral and mean absorption characteristics of solid and gaseous elemental materials which might be utilized to control the transfer of radiant energy in the propellant region of a gaseous nuclear rocket engine. Spectral extinction, absorption and scattering parameters were calculated, based on the Mie theory, for spherical molybdenum, niobium, tantalum, and cadmium particles having radii of 0.01, 0.05, 0.10, and 0.50$\mu$. Similar calculations were made for spherical tungsten particles at five temperatures between 1600°K and 2400 K°. The tungsten calculations were based on analytically extrapolated refractive indices for wavelengths between 0.1 and 30$\mu$ at each temperature. The Rosseland mean absorption parameter of spherical tungsten particles having a radius of 0.05$\mu$ was calculated for temperatures between 1000°K and 5600°K. In addition, the spectral absorption parameters and normal spectral reflectivities of bulk aluminum, cadmium, carbon, cobalt, hafnium, iridium, iron, molybdenum, niobium, nickel, palladium, platinum, silicon, tantalum, thallium, titanium, tungsten, vanadium, and zirconium were calculated. The bulk absorption parameters apply to seeds in the form of thin plates and are generally higher than those for seeds in the form of spherical particles. Average reflectivities for normally incident radiation, determined by weighting the normal spectral reflectivities with respect to the blackbody radiation function, were computed for aluminum, copper, gold, nickel, silver, and tungsten. The spectral absorption coefficients and Rosseland mean opacity of gaseous tungsten were re-evaluated using the UARL heavy-atom model with a modified oscillator strength distribution function. Additional average local line spacing and local line intensities for materials which might be used as gaseous seed agents were calculated. These materials include neutral iron, silicon, uranium, and vanadium as well as singly ionized niobium, tungsten, and vanadium. (auth)

**605** EXCITATION OF NEUTRAL ATOMS BY ELECTRON IMPACT. Presnyakov, L.; Sobelman, I.; Vainshtein, L. (Lebedev Inst. of Physics, Moscow). Proc. Phys. Soc. (London), 89: 511-13(Nov. 1966).

A method which takes account of electron-electron repulsion has been proposed for calculating cross sections for the excitation of neutral atoms. Recently Crothers and McCarroll suggested some modifications of this method. These modifications, and some difficulties arising in particular from using the complex effective charge, are discussed. Some results concerning the excitation of the sodium atom by electron impact are presented. (auth)

**606** SCATTERING OF IONS BY CRYSTALS. Mashkova, E. S.; Molchanov, V. A. (Lomonosov State Univ., Moscow). Soviet Phys.-Solid State (Engl. Transl.), 8: 1206-9(Nov. 1966).

Translated from Fiz. Tverd. Tela, 8: 1517-21(May 1966).

The results of an investigation of the energy spectra of inert-gas ions of 25–30 keV scattered by the (100) and (114) faces of a copper crystal show that, under some conditions, doubly scattered ions predominate in a beam scattered from a crystal. It is mentioned that a very much idealized model of the process predicts qualitatively but correctly the observed relationships. (auth)

**607** INVESTIGATION OF THE STATE OF IODINE MOLECULES BEHIND A SHOCK-WAVE FRONT. Generalov, N. A.; Losev, S. A.; Kosynkin, V. D.; Ovechkin, V. Ya. Vestn. Moskov. Univ., Ser. III: Fiz. Astron., No. 6, 29-36(Nov.-Dec. 1965). (In Russian).

At temperatures greatly exceeding vibrational temperatures $\Theta$, the molecules may be excited and decomposed at the same time. This problem was more closely examined on vapors of iodine which possess a $\Theta$ = 306°K. The study was greatly simplified by the fact that the absorption spectrum of iodine molecules lies in the visible range, as a result of the transition from the ground electron state to the excited state. It is thus possible to compare the spectral characteristics of iodine under stationary heating in a furnace and in a shock-wave tube at 100 to 1500°K, as the molecules undergo not only excitation but also partial decomposition. High-intensity shock waves may be easily created in a heavy gas, such as iodine vapors; however, the chemical activity of this element limits the choice of structural materials. Absorption properties of the iodine molecules behind the shock-wave front were determined in the 760 to 5600°K range, deriving an equation which correlates the velocity of the shock-wave front, the mass of the iodine molecules, their dissociation energy, the initial energy of the gas, and the vibrational energy. From these data, the dissociation rate constant in the 1000 to 4000°K range was determined: it varied from $1 \times 10^8$ to $1.5 \times 10^{11}$ $(\text{mole sec})^{-1}$ $\text{cm}^3$. (TTT)

**608** UNIFORM APPROXIMATION FOR POTENTIAL SCATTERING INVOLVING A RAINBOW. Berry, M. V. (Bristol Univ., Eng.). Proc. Phys. Soc. (London), 89: 479-90(Nov. 1966).

In scattering situations characterized by the appearance of a rainbow, the scattering sum converges very slowly. To calculate the differential cross section in such cases the sum is transformed by the Poisson summation formula into a series of integrals, each of which is evaluated by the method of stationary phase. Previous work along these lines has led to the classical, "crude semi-classical" and Airy approximations. Using a method due to Chester, Friedman, and Ursell a uniform approximation is derived, valid for all angles irrespective of whether they are near or far from the rainbow angle. This new approximation involves only those quantities needed to solve the equivalent purely classical problem; it also reduces to the earlier results in appropriate limiting cases. For a particular numerical example of scattering by a Lennard–Jones potential the uniform approximation is found to agree very well with the results of an exact calculation by Hundhausen and Pauly. (auth)

**609** CLASSICAL CROSS SECTIONS FOR IONIZATION OF HYDROGEN ATOMS BY ELECTRONS. Abrines, R. (Kingston Coll. of Tech., Surrey, Eng.); Percival, I. C.; Valentine, N. A. Proc. Phys. Soc. (London), 89: 515-23(Nov. 1966).

Classical Monte Carlo cross sections are obtained for the ionization from the ground level of the hydrogen atom by electrons with twelve energies between threshold and 540 eV. Statistical errors are about 5% down to E = 43.5 eV, and become relatively larger as the cross section decreases toward the threshold, with the exception of E = 34 eV, where the calculations are more extensive. Cross

sections are less than experiment at high energies, and greater at low energies, where there is a marked improvement on classical impulse approximations. Experiment and Monte Carlo cross sections agree at approximately 60 eV. The cross sections and energies are scaled so that they apply to atoms which are initially in excited levels, when the classical theory is better. The cross section is independent of the initial angular momentum $l_i$ of the bound electron, except for a slight bias towards high $l_i$, especially at large modified impact parameter. The distribution of energy $\Delta E$ transferred to the bound electron is compared with Vriens' classical impulse approximation and the Born approximation. The classical impulse approximation is of little value for excitation. (auth)

**610** SPECTRUM OF THE ENERGY OPERATOR IN SUBSPACES CORRESPONDING TO IRREDUCIBLE REPRESENTATIONS OF PERMUTATION GROUPS FOR ATOMS WITH STATIONARY NUCLEI. Zhislin, G. M.; Sigalov, A. G. Izv. Akad. Nauk SSR, Ser. Mat., 29: 835-60(1965). (In Russian).

The spectrum of the singular differential operator $H = T_n + V_n + W_n$ is studied, where $T_n$ is the kinetic energy operator for n electrons, $V_n$ is the Coulomb potential of the electrons in the field of an infinitely massive nucleus, and $W_n$ is the sum of the pair Coulomb interaction operators for the electrons. H acts on the Hilbert space of complex-valued functions of 3n independent variables, possessing a definite permutation symmetry. Applying group-theoretical methods of E. Wigner and the theory of partial differential equations, earlier investigations in spectral theory are continued. The existence of an infinite sequence of proper values is established for every type of physically realizable permutation symmetry. If the symmetry is disregarded, H has an infinite set of isolated proper values converging to some $\mu < 0$. All points to the right of $\mu$ form the "limiting spectrum." Taking account of symmetry, it is found that all (except, possibly, a finite number of the eigenvalues of H) lie in the limiting spectrum if $n \geq 4$. The general results obtained are compared with previous work and various special cases. (ATD)

**611** A STUDY OF LYMAN $\alpha$ EMISSION IN CHARGE-TRANSFER COLLISIONS INVOLVING 40- TO 200-keV PROTONS. Ryding, G.; Wittkower, A. B.; Gilbody, H. B. (London Univ.). Proc. Phys. Soc. (London), 89: 547-52 (Nov. 1966).

Relative cross sections for the 2s capture process $H^+ + X \rightarrow H(2s) + X^+$ were determined for targets of hydrogen and helium by studying the Lyman $\alpha$ radiation emitted during electric field quenching of the fast H(2s) atom collision products. The ratio of the cross section for 2s capture in atomic hydrogen to that in molecular hydrogen was also determined by using a tungsten furnace to contain the target gas. (auth)

**612** AN EXPERIMENTAL STUDY OF CHARGE TRANSFER IN PROTON–ATOMIC HYDROGEN COLLISIONS USING A FURNACE TARGET METHOD. Wittkower, A. B.; Ryding, G.; Gilbody, H. B. (London Univ.). Proc. Phys. Soc. (London), 89: 541-6(Nov. 1966).

The charge neutralization of protons during passage through an atomic-hydrogen furnace was studied in the energy range 40 to 250 keV. The variation of the ratio $Q_1/Q_2$ of the charge transfer cross sections in atomic and molecular hydrogen was found to be fairly consistent with the recent data of McClure up to 117 keV. Above 110 keV the ratio appeared to reach a steady value of $0.42 \pm 0.03$. Cross sections $Q_1$, estimated by the use of known values of $Q_2$, were generally consistent with the calculations of Jackson and Schiff at impact energies above 110 keV. (auth)

**613** PICKOFF QUENCHING OF ORTHOPOSITRONIUM IN HELIUM. Fraser, P. A.; Kraidy, M. (Univ. of Western Ontario, London, Can.). Proc. Phys. Soc. (London), 89: 533-9(Nov. 1966).

The measurement by Duff and Heymann in 1962 of the pressure-proportional pickoff quenching rate of orthopositronium in helium gas may be interpreted as giving an effective number of electrons per atom in a singlet state relative to the positron of $0.108 \pm 0.010$ for thermal orthopositronium kinetic energies. A trial wave function used in the study of collisions of orthopositronium with helium, arising from an extension of work by Fraser in 1962, is employed to calculate this effective number of electrons. The unsatisfactory result at low energies is 0.019. A possible improvement in the collision trial wave function is suggested. (auth)

**614** ITERATION AND ITERATION–VARIATION METHODS FOR THE ELASTIC SCATTERING OF ELECTRONS BY ATOMS. Kraidy, M.; Fraser, P. A. (Univ. of Western Ontario, London, Can.). Proc. Phys. Soc. (London), 89: 525-32(Nov. 1966).

The coupled integro-differential equations arising in the study of the elastic scattering of electrons by atoms have been solved by various methods: iterative, non-iterative, and variational. A further iteration procedure, based on an alternative asymptotic form of the wave functions, followed by an iteration–variation method in which the trial wave functions are expressed as linear combinations of only two iterated functions is presented. The first allows convergence in some cases where a previous iterative method has failed, and the latter generally increases the convergence speed. The examples given are all from the electron–hydrogen atom collision problem. (auth)

**615** SPECIFIC PROPERTIES OF THE RELATIVISTIC POSITRON EMISSION IN A MAGNETIC FIELD. Ternov, I. M.; Rzaev, R. A. Vestn. Moskov. Univ., Ser. III: Fiz. Astron., No. 6, 87-9(Nov.-Dec. 1965). (In Russian).

Polarization of the radiation emitted by positrons with oriented spin while passing through a homogeneous magnetic field was investigated, using the positron wave function which satisfies the Dirac equation. In order to analyze the Dirac equation for the spin states, the wave function was made an eigenfunction of the operator tensor of the polarization. The calculations indicated that in the upper half-plane the electron emits a right-polarized light and the positron a left-polarized light; in the lower half-plane the signs are interchanged. In the quantum approximation, the linear polarization components also change signs. It was found that during the simultaneous passage of spin-polarized electrons and positrons possessing the same energy in the magnetic field for a relatively long time period, the spins of the particle assume opposite orientations with respect to each other. (TTT)

**616** ATOM-ATOM SCATTERING EXPERIMENT: VELOCITY DEPENDENCE OF TOTAL CROSS SECTIONS. Beck, D.; Loesch, H. J. (Univ., Freiburg i. B.). Z. Phys., 195: 444-60(1966). (In German).

The velocity dependence of total cross sections for the collision partners Cs–Hg, K–Hg, Xe, Kr, Ar was measured in crossed beams. Except for Cs–Hg, scattering oscillations were resolved. Invariably good agreement with theoretical predictions is found for the extrema velocities assuming $n = 6$ potentials with $8 \leq n \leq 16$ or $\exp - 6$ potentials with $10 \leq \alpha \leq 18$, for the amplitudes of the oscillations no fit is obtained. K–Hg, probably also K–Xe and K–Kr appear to deviate from the $v^{-\frac{1}{3}}$ average velocity dependence expected for dipole-dipole interaction at large distances. (auth)

**617** INFLUENCE OF SURFACE DEFECTS ON SPUTTERING. Vernickel, H. (Institut fuer Plasmaphysik, Garching, Ger.). Z. Naturforsch., 21a: 1308-9 (Aug. 1966).

The sputtering of tungsten monocrystals with rare-gas ions under ultrahigh vacuum conditions was observed in a field emission microscope (FEM) at temperatures between 90 and 900°K. The resultant FEM pattern depends strongly on the crystal temperature during bombardment. This is ascribed to the influence of the defects produced by bombardment. (M.H.R.)

**618** THE MICROWAVE ROTATION SPECTRUM OF GeSe. Hoeft, J. (Freie Univ., Berlin). Z. Naturforsch., 21a: 1240-3(Aug. 1966). (In German).

In the frequency region 11 to 29 GHz, at temperatures between 430 and 500°C, rotation transitions of 18 isotope combinations of GeSe were measured. Rotation constants, nuclear spacings, and mass ratios of germanium and selenium isotopes are given. For the nuclear spacing of GeSe the value $r_e = (2.134632 \pm 0.000063)$ Å was obtained. From the quadrupole hyperfine structure of a rotation transition of $^{73}Ge^{80}Se$ follows for the nuclear quadrupole coupling constant of $^{73}Ge$: $eqQ = (+175 \pm 3)$ MHz. (tr-auth)

**619** ZEEMAN-EFFECT INVESTIGATIONS IN SAMARIUM I SPECTRUM. Heilig, Klaus; Sauthoff, Gerhard; Steudel, Andreas (Technische Hochschule, Hanover). Z. Phys., 196: 39-43(1966). (In German).

Zeeman effect investigations in Sm I were made in the 3350 to 6700 Å range at field strengths of approximately 25 kOe. Twenty-six J values of those terms, for which Albertson gave two J values, were determined; 4 J values of Albertson had to be changed. 28 $g_j$ values were measured. (auth)

**620** LEVEL-CROSSING STUDY OF HYPERFINE STRUCTURE OF $3d^{10}4p^2P_{\frac{1}{2}}$ TERMS OF $^{63}Cu$ AND $^{65}Cu$. Ney, Josef (Technische Univ., Berlin). Z. Phys., 196: 53-65(1966). (In German).

The level-crossing technique was used to investigate the hyperfine structure of the $3d^{10}4p^2P_{\frac{1}{2}}$ term in Copper I by scattering the resonance line $\lambda = 3248$ Å on an atomic beam of separated $^{63}Cu$ and $^{65}Cu$ in an external magnetic field. From the level-crossing signals values for the magnetic dipole interaction constants A and for the electric quadrupole interaction constants B are deduced. With the A value of the $3d^{10}4p^2P_{\frac{1}{2}}$ term from optical measurements the ratio $A(^2P_{\frac{3}{2}}) : A(^2P_{\frac{1}{2}}) \approx 0.4$ is about twice greater than for an unperturbed alkali-like $^2P$ term. From the width of the level-crossing signals a mean lifetime of the $3d^{10}4p^2P_{\frac{1}{2}}$ term $\tau = (7.0 \pm 0.2) \cdot 10^{-9}$ sec is deduced. (auth)

**621** ENERGY DISTRIBUTION OF 1-Mev ELECTRONS IN ELECTRON-ELECTRON SCATTERING. Braunschweig, M.; Knop, G.; Minten, A. (Univ., Bonn). Z. Phys., 196: 285-97(1966). (In German).

The energy distribution of 1-MeV electrons scattered at 30° by Al, Cu, and Ag is measured in the region of electron-electron scattering. The broadening of the distribution by the internal motion of the atomic electrons and by multiple scattering is investigated, especially in comparison with the energy loss by bremsstrahlung. (auth)

**622** EXCITATION OF CARBON OXIDES BY PROTONS. Poulizac, Marie-Claude; Desesquelles, Jean; Dufay, Maurice (Paris Univ., Lyon). Compt. Rend., Ser. B, 263: 553-6(Aug. 22, 1966). (In French).

The three band systems, $B^2\Sigma \rightarrow {}^2\Sigma$, $A^2\Pi \rightarrow {}^2\Sigma$, and $B^2\Sigma \rightarrow A^2\Pi$ of $CO^+$ were excited by accelerated protons at 20 to 600 kev. The effective excitation cross sections were measured for the states $B^2\Sigma$ and $A^2\Pi$. The vibrational structures correspond to those at higher temperatures. The dissociation reactions are weak and the transitions from CI, CII, OI, and OII are of small intensity. The total ionization and charge exchange effective cross sections, as well as the effective cross section for $H^+$ ion production, were also measured between 20 and 600 kev. (tr-auth)

**623** CROSS SECTIONS AND REACTION RATES FOR EXCITATION AND IONIZATION OF ATOMS BY ELECTRON COLLISIONS. Carson, T. R. (St. Andrews Univ., Fife, Scotland). J. Quant. Spectros. Radiative Transfer, 6: 563-74(Sept.-Oct. 1966).

The excitation and ionization of atoms by electron collisions is treated in the Born-Bethe approximation. A modification is used to obtain simple analytical functions which represent the cross sections over the entire range of impact energies, for both allowed and forbidden transitions. While the formulas cannot be expected to be quantitatively of high accuracy except at high energies, they do show the right qualitative behavior everywhere and, in addition, possess valuable integral properties. (auth)

**624** BORN APPROXIMATION CALCULATION OF THE EFFICIENT CROSS SECTIONS FOR THE EXCITATION OF HELIUM ATOMS BY PROTONS BETWEEN 100 kev AND 1 Mev. Gaillard, Michel (Paris Univ., Lyon). Compt. Rend., Ser. B, 263: 549-52(Aug. 22, 1966). (In French).

The total effective cross sections for exciting the $4\ ^1S$, $5\ ^1S$, $6\ ^1S$; $2\ ^1P$, $3\ ^1P$, $4\ ^1P$, $5\ ^1P$; $3\ ^1D$, $4\ ^1D$, $5\ ^1D$; and $4\ ^1F$ levels of the helium atom through proton bombardment between 100 kev and 1 Mev were calculated using the Born approximation. (tr-auth)

**625** DIFFERENTIAL CROSS SECTION FOR EXCITATION OF THE $2^3S$ AND HIGHER STATES OF He BY 600-ev $He^+$ IONS. Lorents, D. C.; Aberth, W.; Hesterman, V. W. (Stanford Research Inst., Menlo Park, Calif.). Phys. Rev. Lett., 17: 849-51(Oct. 17, 1966).

Measurements of the differential cross section for excitation of the $2^3S$ state of He by 600-eV $He^+$ ions are reported. Pronounced regular oscillations are observed in the angular dependence of the cross section. Similar behavior is observed qualitatively in the excitation of higher states. (auth)

**626** ENERGY LOSSES AND CHARGE STATES OF HEAVY IONS ON PASSAGE THROUGH MATTER. Bethge, K.; Sandner, P.; Schmidt, H. (Univ., Heidelberg). Z. Naturforsch., 21a: 1052-6(July 1966). (In German).

Energy losses of B, N, O, and S ions in gold, silver, and nickel targets were measured by a new method, based on the elastic backward scattering of these ions from thick targets. The agreement of the results with semiempirical estimates of Northcliffe is excellent as far as these estimates are made. Charge distributions of O and S ions after scattering from thick targets were also measured and the values of $\gamma^2$ determined. The energy losses calculated from these $\gamma^2$ values agree within the errors with the directly measured values. (auth)

**627** MASS SPECTROMETRIC ANALYSIS OF NEUTRAL PARTICLES SPUTTERED FROM A (110) GaAs CRYSTAL BY LOW ENERGY ARGON IONS. Comas, James; Cooper, C. Burleigh (Univ. of Delaware, Newark). 6p. (CONF-660633-3). ORAU. Gmelin, AED-CONF-66-199-19.

From American Physical Society, Division of Plasma Physics, Minneapolis, Minn.

Results of a mass-spectrophotometric study of the particles sputtered from a (110) and (111) GaAs crystal by low-energy argon ions are reported. The results indicate that the majority of the particles ejected from the target are atomic and neutral. Apparently, the crystal surface is stoichiometrically sputtered. The mass spectrometer is described in some detail, and the scans are shown in graphical form. (B.L.M.)

**628** SOME CHARACTERISTICS OF ELECTRON-IMPACT ION SOURCES. Clampitt, R. (Bristol Univ., Eng.). 10p. (CONF-660537-3). ORAU. Gmelin, AED-CONF-66-175-4.

From 14th Annual Conference on Mass Spectrometry and Allied Topics, Dallas.

Instrumental effects pertaining to ion sources of the Nier and Fox types are discussed. The effects of electron accelerating potential on scattering of electrons at the edges of the beam-defining slit are considered. Results of measurements on the potential of the electron beam as a function of electron current for various gas pressures are shown. At high electron currents, gas pressure affects significantly the potential of the beam. (A.G.W.)

**629** MICROANALYSIS OF SURFACES BY ION BEAM SCATTERING. Peisach, Max (Southern Universities Nuclear Inst., Faure, South Africa); Poole, Darrell O.

28p. (CONF-660414-9). ORAU. Gmelin, AED-CONF-66-119-12.

From 2nd International Conference on Electron and Ion Beam Science and Technology, New York.

The elastic scattering of singly charged hydrogen, helium and nitrogen ions was used to develop a method for the analysis of surfaces. When a monoenergetic beam of accelerated ions was scattered off a surface, the maximum energy of the ions scattered through a selected angle served as a means of identifying the mass of the scattering nucleus and the intensity of the scattered beam was used to determine the surface concentration of the scatterer at the point of incidence of the beam. Heavy elements such as gold and tin were determined over areas of about $5 \times 10^{-3}$ cm$^2$ with a sensitivity of better than 0.2 μg/cm$^2$. The sensitivity for light elements, such as oxygen, is somewhat less because the low-energy ions scattered from within the sample contribute to the count rate of low-energy particles scattered from surface layers of light elements. However, the thickness of aluminum oxide layers on aluminum produced by anodizing were measured with a precision of ±3%, and self-supporting thin films of light elements were measured with the same precision. Thin slices of geological samples were analyzed qualitatively and semiquantitatively. The method is also capable of application to the measurement of oxide film composition on corroded surfaces. Comparative studies were carried out to determine over what range of mass numbers the variation of scattered energy per unit mass is optimum for each type of bombarding particles. For mass numbers up to 7, 7 to 28, and 28 upwards, it was found that hydrogen, helium and nitrogen ions respectively were the preferred particles for analysis. A nomogram is presented to select experimental conditions for the required degree of resolution and to enable the rapid identification of surface elements to be made from experiment data. (auth)

**630** MOMENTUM TRANSFER TO SURFACES BY $N_2$ MOLECULES IN THE 10 TO 200 ev RANGE. Humphris, R. R.; Boring, J. W. (Univ. of Virginia, Charlottesville, Va.). 10p. (CONF-651135-8). ORAU. Gmelin, AED-CONF-65-402-16.

From American Physical Society, Southeastern Section, Charlottesville, Va.

A system was developed for producing a neutral $N_2$ beam in the energy range 10 to 200 eV with a particle flux at 10 eV of $2 \times 10^{10}$ mol/sec. The force produced by this beam ($\sim 10^{-6}$ dyne) on a test surface was measured with a torsion balance. The beam was produced by charge transfer neutralization of a $N_2^+$ ion beam with the neutralizing gas being pumped cryogenically. (auth)

**631** MASS SPECTROMETRY OF BACKGROUND GASES IN GLOW DISCHARGE SPUTTERING OF TANTALUM THIN FILMS. Sosniak, J. (Bell Telephone Labs., Inc., Murray Hill, N. J.). 57p. (CONF-651046-7). ORAU. Gmelin, AED-CONF-65-403-12.

From 12th National Symposium of the American Vacuum Society, New York.

The composition of the ambient atmosphere during the sputtering of tantalum films was studied by means of a mass spectrometer adapted both for residual analysis of vacua between $10^{-9}$ to $10^{-5}$ torr and process monitoring at pressures of (10 to 15) $\times 10^{-3}$ torr. The partial pressures of a number of residuals were found to increase immediately on the initiation of the discharge in both an oil diffusion and a turbomolecular pump system. The total background gas levels during the discharge were in the $1 \times 10^{-5}$ to $5 \times 10^{-4}$ torr range, with the major component being hydrogen, and smaller contributions from water vapor and methane. The pressure increase of these species results from ion bombardment of adsorbed surface layers, and has a complex time dependence characterized by two maxima. The spectrometer was used for detailed studies of the gettering of deliberate additions of $N_2$, $O_2$, $CH_4$, and $H_2$ during sputtering in argon. Considerable differences were found in the effect of the glow discharge on those gases, with the gettering of $CH_4$ and $H_2$ exhibiting a complex time dependence. It is shown that the observed gettering rates can be used to predict the gas content of the sputtered films. Tantalum films sputtered without deliberate gas additions were found to be of the beta-tantalum form even when the discharge-generated background was reduced to $\sim 1 \times 10^{-6}$ torr by long presputtering. (auth)

**632** ONE-CENTER CALCULATION OF THE He–He REPULSION. Morris, B. M.; Present, R. D. (Univ. of Tennessee, Knoxville). 18p. (CONF-651135-6). ORAU. Gmelin, AED-CONF-65-402-20.

From American Physical Society, Southeastern Section, Charlottesville, Va.

Earlier one-center calculations were extended, through the inclusion of additional configurations, to apply to internuclear distances of 0.75 and 1.0 a.u. The configurations investigated were $1s^2\ 2s^2$, $1s^2\ 2p\sigma^2$, $1s\ 3d\sigma\ 2s^2$, $1s^2\ 2s\ 3d\sigma$, $1s\ 3d\sigma\ 2p\sigma^2$, $1s\ 2s\ 2p\sigma^2$, $1s\ 5g\sigma\ 2p\sigma^2$, $1s\ ns\ 2p\sigma^2$, and $ns^2\ 2p\sigma^2$. The best three-configuration mixture $1s^2\ 2p\sigma^2 + 1s\ 3d\sigma\ 2p\sigma^2 + 3s^2\ 2p\sigma^2$ gave the same energy as Ransil's two-center single-configuration LCAO-MO calculation at R = 0.75 a.u. but is 8 ev above the Ransil result at R = 1 a.u. The two-center calculation of Buckingham and Duparc, using a mixture of $(\sigma_g\ 1s)^2\ (\sigma_g\ 2s)^2$ and $(\sigma_g\ 1s)^2\ (\sigma_u\ 1s')^2$ configurations (the latter due to Huzinaga) gave better results than were obtained at distances of 0.5 and 0.75 a.u. (auth)

## Cosmic Radiation

*Refer also to abstract 781.*

**633** (NYO-3164-2, Lect. 7) COSMIC RADIATION. Linsley, John (Massachusetts Inst. of Tech., Cambridge). 12p.

Natural corpuscular radiation in space with energy, or energy per nucleon, greater than $10^{10}$ eV is considered. Modulation effects are not included. Solar cosmic rays are mentioned only in connection with the properties that set them off as a distinct phenomena. The origin and energy density of galactic and extragalactic corpuscular radiation are discussed. Methods of measurement are mentioned. (W.D.M.)

**634** ENERGY BALANCE OF COSMIC RAYS. Rozental, I. L. (Moscow Engineering Physics Inst.). Soviet Astron.-AJ (Engl. Transl.), 10: 264-9(Sept.-Oct. 1966).

Translated from Astron. Zh., 43: 332-9(Mar.-Apr. 1966).

The channels by which the energy of the nuclear and electron components of cosmic rays is dissipated in the Galaxy and Metagalaxy are analyzed. The manner in which energy lost to ionization is transformed is considered in detail. Ultimately, the ionization energy goes into the energy of slow electrons (~10 to 100 eV). A large fraction (~75%) of the energy of slow electrons is used up in the excitation of interstellar hydrogen [mainly via the (1s − 2p) transition], which is then reemitted. The further fate of the ultraviolet radiation is discussed. Some of the energy is lost in the production of bremsstrahlung photons by secondary electrons. A comparatively larger fraction of the energy in this intermediate mechanism is spent in the production of x rays. (auth)

**635** PRODUCTION OF LOW-ENERGY COSMIC-RAY ELECTRONS. Abraham, P. B.; Brunstein, K. A.; Cline, T. L. (Goddard Space Flight Center, Greenbelt, Md.). Phys. Rev., 150: 1088-1103(Oct. 28, 1966).

The production of cosmic-ray electrons of characteristically low energies is investigated. Secondary sources, other than that of meson decay, are considered, and constraints are placed on both secondary and primary sources. (1) Calculations are made of the intensity of low-energy knock-on and beta-decay electrons which are secondary to cosmic-ray interactions. In particular, knock-on production is calculated in the 100-KeV to 50-BeV kinetic-energy interval. Interstellar losses due to ionization, leakage from the galaxy, and synchrotron, bremsstrahlung, and in-

verse Compton effects are considered, as well as those due to plasma excitation, the red shift and synchrotron, bremsstrahlung, and inverse Compton effects in the intergalactic medium. The intensity of low-energy relativistic electrons from these sources is not negligible compared with the low energy $\pi \rightarrow \mu \rightarrow e$ intensity, but it is shown not to account for the observed interplanetary electron intensity. (2) Energy inputs to the injected secondary electrons by a possible solar electric field of low magnitude and by a possible galactic Fermi acceleration are investigated. It is shown that at least one such input is necessary if the observed low energy interplanetary electron intensity is to be attributed to secondary production alone. A heliocentric field which does allow for a fit to the low-energy data cannot, however, account for the high-energy BeV electrons found to be in excess of those from $\pi \rightarrow \mu \rightarrow e$ production. The Fermi acceleration shown to be necessary to provide a fit is greater than that usually postulated for cosmic-ray protons, and also requires that the ratio of escape losses to acceleration $\lambda/\alpha$ be much smaller than is usually assumed for protons. This distinction is acceptable only if one postulates a significant difference between interstellar proton and electron propagation. (3) The observation that the velocity spectrum of electrons in the energy-per-unit-mass region of 7–25 closely approximates that of the cosmic-ray protons, and the necessity of constraints on the secondary-electron hypothesis outlined above, suggest that most of the low-energy electrons are of primary origin. The similarity between this conclusion and the conclusion (based on the measurement of the charge ratio of electrons) that the higher energy electrons are mostly primary is discussed. (auth)

**636** NEUTRINO ASTRONOMY. Reines, Frederick (Univ. of California, Irvine). Science, 2: No. 10, 84-9 (Oct. 1966).

The possibilities of neutrino astronomy are briefly discussed along with neutrino production in space, in the atmosphere, and in stars. Various experiments on detecting neutrinos from the sun including the BNL neutrino detector, Case-Witwatersrand lithium neutrino detector, University of Utah Cherenkov and spark counters, and the Case-Witwatersrand elastic scattering neutrino detector are summarized. (W.D.M.)

**637** ABUNDANCES AND ENERGY SPECTRA OF GALACTIC COSMIC-RAY NUCLEI ABOVE 20 MeV PER NUCLEON IN THE NUCLEAR CHARGE RANGE $2 \leq Z \leq 26$. Comstock, G. M.; Fan, C. Y.; Simpson, J. A. (Univ. of Chicago). Contract NAS-5-2133. Astrophys. J., 146: 51-77(Oct. 1966).

The individual abundances of the elements helium through silicon, as well as the nuclear-charge group $15 \leq Z \leq 25$ and the Fe–Ni group, have been measured using a telescope composed of solid-state detectors on the OGO-I satellite in the period October 1964, to June 1965. Also measured were the differential energy spectra for He, B, C, and O over the energy range ~20 to 1000 MeV per nucleon, with some integral measurements above 1000 MeV per nucleon. The spectra for Ne, Mg, and the Fe–Ni group were obtained over a narrower energy range. The experimental results are divided into two time intervals approximately 6 months apart in order to investigate the dependence of abundances and energy spectra upon changes in solar modulation. The abundances of the elements in the kinetic energy range ~20 to ~330 MeV per nucleon are normalized to oxygen with a flux of $5.4 \times 10^{-6}$ nuclei $m^{-2}$ $sec^{-1}$ $ster^{-1}$ $(MeV/nucleon)^{-1}$. The ratio of abundances of nuclei with even-to-odd nuclear charge number Z, especially in the range $6 \leq Z \leq 14$, is approximately 8 : 1. The elements Li, Be, and B are present down to the lowest observed energies in the approximate ratio 2 : 0.7 : 2.5. The ratio (Li, Be, B) : (C, N, O) = 0.26 ± 0.04. The abundance of the Fe–Ni group relative to C and O is nearly equal to its abundance at high energies. For nuclei $5 \leq Z \leq 14$ the differential energy spectra are remarkably independent of energy below ~300 MeV/nucleon. It is shown that the spectra for these nuclei, when extrapolated to the nearby interstellar medium, must be continuously rising toward the lowest observed energies (~20 MeV/nucleon) with greater negative slopes than for the He spectrum. Experimental evidence for the galactic origin of these nuclei is presented. The bearing of this experiment on the origin and propagation of cosmic-ray nuclei is discussed, and it is pointed out that some assumptions commonly accepted are no longer tenable. Two specific alternatives are considered. It appears that energy degradation by ionization loss alone may not account for the results. It is suggested that the rate of particle acceleration for a wide range of Z competes effectively with the rate of ionization loss at these low energies. Alternatively, a discrete, and possibly nearby, source in the Galaxy could account for these low-energy measurements. Since the technique of using solid-state devices for measuring multiply charged nuclei is novel, a description of the instrument and the methods for analyzing the data are given. (auth)

**638** INTERPRETATION OF THE CHARGE RATIO OF COSMIC-RAY MUONS. MacKeown, P. K.; Wolfendale, A. W. (Univ. of Durham, Eng.). Proc. Phys. Soc. (London), 89: 553-65(Nov. 1966).

From a survey of all the available experimental data on the charge ratio of muons in cosmic radiation a best estimate of its energy dependence is presented, both in the vertical direction and at large zenith angles. A discussion is given of the relevant parameters for its interpretation and the predictions of various models of particle production are investigated. It is found that pionization alone is unable to explain the data, even allowing for fluctuations in inelasticity and multiplicity to the extent observed in other high-energy experiments. The parameters of models involving kaon and pion production needed to explain the ratio are determined. At present, explanation in terms of kaon production is slightly more probable. (auth)

**639** A THEORETICAL ANALYSIS OF EXTENSIVE AIR SHOWERS. I. NEAR-VERTICAL SHOWERS AT SEA LEVEL. De Beer, J. F.; Holyoak, B.; Wdowczyk, J.; Wolfendale, A. W. (Univ. of Durham, Eng.). Proc. Phys. Soc. (London), 89: 567-85(Nov. 1966).

Calculations were made of some features of extensive air showers expected in the near-vertical direction at sea level for three models for the nucleon–air-nucleus, and pion–air-nucleus interaction. The models were chosen with regard to known experimental features of interactions of energy up to some few thousand BeV and the calculations were made for primary protons and heavy nuclei, the latter using a simple fragmentation model. Detailed comparison between prediction and experiment was made for the energy spectrum and lateral density distribution of muons in showers of size in the region of $10^6$ particles. All the models predict the measured shape of the energy spectrum to several hundred BeV, indicating that the propagation model and the energy spectrum adopted for all three models are acceptable. For muon energy thresholds up to about 10 BeV the predicted lateral distributions agree in shape at radial distances above about 50 m but show a considerable excess over observation at small distances. Much of the discrepancy can be removed by allowing for uncertainty in core location in experimental arrangements and the residue can be eliminated if it is assumed that collisions in which secondaries are emitted with small transverse momenta ($p_t \lesssim 0.1$ BeV/c) are rare. Only one experiment appears to have been carried out at a high energy threshold ($E_\mu > 40$ BeV) and the resulting lateral distribution is somewhat flatter than predicted even after allowance is made for the factors mentioned. If substantiated the most likely explanation is the existence of an excess of interaction secondaries with transverse momenta above several BeV/c. (auth)

**640** THE MOMENTUM SPECTRUM OF COSMIC-RAY MUONS AND THE CHARGE RATIO AT 5200 m ALTITUDE. Allkofer, O. C.; Kraft, E. (Univ., Kiel). Z. Naturforsch., 21a: 1205-10(Aug. 1966). (In German).

The momentum spectrum of cosmic-ray muons and the charge ratio at 5200 m above sea level were measured. To

separate the spectrum of muons from the total spectrum a lead absorber was used. From theoretical models the spectrum of muons is calculated. Good agreement is found between the calculated and measured muon spectrum. (auth)

**641** SIGN RATIO AND ABSOLUTE FLUX OF COSMIC-RAY ELECTRONS. Bland, C. J. (Univ., Milan. Consiglio Nazionale delle Ricerche, Milan); Boella, G.; Antoni, G. Degli; Dilworth, C.; Scarsi, L.; Sironi, G.; Agrinier, B.; Koechlin, Y.; Parlier, B.; Vasseur, J. Phys. Rev. Lett., 17: 813-16(Oct. 10, 1966).

Two balloon flights were carried out over southern France to measure with high precision the value of the flux of cosmic electrons and to investigate the sign ratio of the electrons of energy about 5 Bev as revealed by the east–west asymmetry of the integral flux. The apparatus used consisted of a multiplate spark chamber containing 5 radiation lengths of lead and triggered for shower detection by a plastic-scintillator counter telescope. The experimental results are described. (M.O.W.)

**642** ATMOSPHERIC TIDE MEASUREMENTS BY COSMIC RAY INTENSITY. Mason, G. R.; Pearce, R. M. 6p. (CONF-650664–11). ORAU. Gmelin, AED-CONF-65-468-1.

From Canadian Association of Physicists Congress, Vancouver, B. C.

A brief description of the University of Victoria Super Monitor for detection of cosmic-ray neutrons is presented. Only one of the recommended three banks of six counters is operating, but the second bank is under construction, and the third bank is planned. Some analyses which have been made of the monitor data pertaining to atmospheric oscillations are described. (W.D.M.)

## Direct Energy Conversion

**643** (AD–635459) RESEARCH ON PLASMA PROPERTIES OF MAGNETOPLASMADYNAMIC POWER GENERATORS. Final Technical Report, May 1, 1963–April 30, 1966. Rosebrock, Theodore L.; Koch, Robert L.; Tipton, Donald L.; Whitaker, Ronald O.; Schneider, Richard T. (General Motors Corp., Indianapolis, Ind. Allison Div.). May 31, 1966. Contract Nonr-4104(00). 100p. (EDR–4637). CFSTI $4.00 cy, $0.75 mn.

The initial objective of the program was to obtain basic information on the plasma properties of working fluids for magnetoplasmadynamic (MPD) power generators. The experimental portion of this initial program centered on a closed plasma diagnostic loop through which helium seeded with cesium was circulated. Test section temperatures were variable between 1000 and 1800°K. New spectroscopic techniques and methods of evaluating observed spectra were developed. The theoretical approach to the problem consisted of developing a mathematical model to describe nonequilibrium plasmas together with supplementary theoretical analyses to aid in design of improved MPD power generators. Instabilities occurring in the plasma flow were treated analytically. Redefinition of program objectives resulted in the demonstration of nonequilibrium ionization in a closed-loop generator operating at 1800°K. The working fluid was helium seeded with cesium. The power output accompanying the nonequilibrium ionization was on the order of a few watts. The severe reduction in power level below theoretical predictions was due to Hall shorting within the generator. (auth)

**644** (AD–635584) DIRECT ENERGY CONVERSION LITERATURE ABSTRACTS. Report No. 11. (Naval Research Lab., Washington, D. C.). June 1966. 122p. CFSTI $4.00 cy, $0.75 mn.

A collection of references from various sources covering the current literature on thermoelectricity, thermionic emission, photoelectric processes, magnetohydrodynamics, electrochemical processes, energy storage, and energy sources is presented. (auth)

**645** (AD–635741) INTENTIONAL COMBUSTION OSCILLATIONS IN PROPULSION SYSTEMS. Final Scientific Report. Swithenbank, J. (Sheffield Univ. (England). Dept. of Fuel Technology and Chemical Engineering). Apr. 25, 1966. Contract AF-EOAR-23-65. 63p. (HIC–74; AFOSR–66-1438). CFSTI $3.00 cy, $0.75 mn.

The power density available from a magnetohydrodynamic (MHD) generator is a function of the plasma velocity and electrical conductivity (which shows an exponential dependence on temperature). An increase in velocity by expansion of the gas through a nozzle can reduce the temperature and consequently the power density. Modulation of these two parameters may be achieved by using combustion oscillations within a MHD generator. The periodic variations in velocity and temperature (hence conductivity) give a higher mean power density. Simple formulae are given by which the increase in power density is demonstrated for combustion oscillations having pressure amplitudes up to unity. Different types of generators are possible in which combustion oscillations provide the required modulation and these are discussed. In order to verify the theory an experiment was designed and constructed to provide the first order travelling tangential mode of combustion oscillation. The instrumentation was developed to cope with the extreme conditions arising in the combustion chamber. Results so far indicate the oscillatory nature of the conductivity. (auth)

**646** (N–66-22823) SOLAR THERMIONIC GENERATOR DEVELOPMENT. Quarterly Report No. 1, November 22, 1965–March 1, 1966. Brosens, Pierre J. (Thermo Electron Engineering Corp., Waltham, Mass.). Contracts NAS7-100; JPL-951263. 65p. (NASA-CR–71742; TE–69-66). CFSTI $3.00 cy, $0.75 mn.

For Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

During this period the first two engineering models, T-201 and T-202, were fabricated and the first one tested. Test results indicate that the interelectrode spacing achieved in this converter was of the order of 1.4 mil instead of the desired 1 mil value. As a result, its performance did not equal that of previously tested converters. Preliminary tests on converter T-202 do not reflect a similar performance loss. The difficulty seems to be related to a lack of good mechanical alignment in the converter assembly and also to a loss of flatness in the converter electrodes resulting from the existing etching processes. All analytic work under Task II was completed. Digital computer results were obtained for 137 different combinations of cavity emissivities, heat input, emitter temperature, aperture size, and number of converters. Results derived from the computations show that even thermal distribution can be achieved by etching or grooving the heated surface of only one family of converters in the generator, and that a thermally balanced generator will remain so even under pronounced changes in the emitter temperature of the converters, and/or in the heat input to the generator cavity. (auth)

**647** (N–66-23680) HIGH-PERFORMANCE THERMIONIC CONVERTER. Quarterly Progress Report, November 13, 1965–February 13, 1966. Campbell, A. E.; Pollock, D. H.; Hamerdinger, R. W.; Worden, D. G. (Electro-Optical Systems, Inc., Pasadena, Calif.). Feb. 15, 1966. Contracts NAS7-100; JPL-951225. 76p. (NASA-CR–71847; EOS–6952-Q-3). CFSTI $3.00 cy, $0.75 mn.

For Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

Basic materials, processes, and operating parameters affecting the stability and optimization of cesium-vapor thermionic converters are being investigated in order to fabricate high-performance, long-life equipment. Cesium-vapor converter output as a function of interelectrode spacing was accurately characterized over the four different regions of converter operation. An optimum cesium pressure-interelectrode distance value of 16 mil-torr was obtained for a polycrystalline rhenium electrode converter operating at a true emitter temperature of 1735°C. Saturated emission densities as high as 180 amps/cm$^2$ were obtained for cesiated polycrystalline rhenium, and mini-

mum work functions of 1.45 to 1.47 eV resulted. Precision cesium conduction heat transfer data were obtained. The variable parameter vehicle has undergone 700 hours of continuous operation without variation in measured quantities; and a thermal mockup of a thermionic converter was shown to provide a direct, optical measurement of the interelectrode spacing. (STAR)

**648** (N-66-23773) APPLIED THERMIONIC RESEARCH. Quarterly Progress Report No. 2, September 25-December 25, 1965. Kitrilakis, S.; Lieb, D.; Rufeh, F. (Thermo Electron Engineering Corp., Waltham, Mass.). [1965]. Contracts NAS7-100; JPL-951262. 25p. (NASA-CR-71292). CFSTI $3.00 cy, $0.75 mn.

For Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

Cesium vapor thermionic conversion processes utilizing cesium fluoride vapor in addition to metallic cesium to provide some freedom in obtaining given electrode work functions, and also using an inert gas in addition to cesium, were studied. The first conversion process was analyzed by evaluation of the Boltzmann region of current voltage characteristics; results were in good agreement with experimental data on the collector work function. Experimental data generated with inert gases in converters led to the development of an analytical framework for data interpretation. Analysis and correlation of surface additive data established that the effects of the additive and the cesium vapors are separable. (STAR)

**649** (NP-16349) HIGH-PERFORMANCE THERMIONIC CONVERTERS. Final Report, May 19, 1965-July 19, 1966. Campbell, A. E. (Electro-Optical Systems, Inc., Pasadena, Calif.). Sept. 2, 1966. Contract 951225. 175p. (EOS-6952-Final).

For Jet Propulsion Lab., Pasadena, Calif.

Development of cesium-vapor thermionic converters is discussed. An investigation on electrode materials is reported, and information on converter design and construction is included. Precise measurements were made of output characteristics for interelectrode spacings in the range from 0.0002 to over 0.010 inch for several settings of emitter, collector, and reservoir temperatures and under optimized power output conditions as well as off-optimum conditions. Fabrication technology is discussed in detail. A procedure for the chemical cleaning of tantalum and the derivation of collector heating power are included as appendixes. (J.H.M.)

**650** (R-66SD47) CONSTANT VELOCITY, ALKALI METAL MHD GENERATOR WITH CONDENSING VAPOR IN QUASI-EQUILIBRIUM WITH CONDENSATE. Smith, J. Marlin (General Electric Co., Philadelphia, Pa. Missile and Space Div.). June 1966. 29p.

The advantages of heat rejection at constant temperature and small pumping power make the Rankine cycle extremely attractive for space power applications. Furthermore limitations on peak nuclear reactor temperatures, desirability of minimizing radiator size, and the fact that superheat does not increase the ideal cycle efficiency indicates the desirability of operating the cycle with little or no superheat and thus generating power in the wet regime. The effect of condensation upon the performance of an MHD generator is considered. The two limits of a condensing system are compared. One limit is that in which the condensation rates are so slow that over the lengths of interest only a negligible amount of condensation takes place. This corresponds to the perfect gas case which has already been extensively investigated. In the second limit the condensation rates are taken to be infinitely fast so that the condensate is in equilibrium with the vapor at saturation conditions. It is found that the later case results in more efficient generator operation due to the heat of condensation which is returned to the gas. (auth)

**651** (ANL-Trans-380) MAGNETOHYDRODYNAMIC FLUX FOR HIGH MAGNETIC REYNOLDS NUMBERS. Velikhov, E. P. (Institut Atomnoi Energii, Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow). Translated by Elmar K. Wilip (Argonne National Lab., Ill.), from paper Presented at the 2nd International Symposium on Magnetohydrodynamic Electrical Power Generation, Salzburg, July 4-8, 1966. 7p. (CONF-660704-184). Dep. mn. CFSTI $1.00 cy, $0.50 mn. JCL $1.10 fs, $0.80 mf.

In liquid-metal magnetohydrodynamic converters the utilization of fluxes with velocities and high magnetic Reynolds numbers is possible and advantageous. Here the conventional setup of a generator with a channel perpendicular to the magnetic field is inapplicable, because the diffusion of the external field into the flux at the entrance region leads to a distortion of the velocity profile and to the appearance of closed currents. This phenomenon is examined for a small ratio of the Alfvén velocity $V_A$ to the velocity V of the flux and for the ratio $V_A/V = A = 1$. The effect of velocity pulsations upon the total effectiveness of the generator channel is estimated, and information is included on the excitation of the Alfvén resonator. (J.H.M.)

**652** DIRECT ENERGY CONVERSION. Sutton, George W. (ed.). Inter-University Electronics Series, Vol. 3. New York, McGraw-Hill Book Company, 1966. 355p. $14.50.

Experimental and theoretical discussions are presented on each of the following energy conversion devices; solar photovoltaic cells, fuel cells, thermoelectric cells, thermionic cells, and MHD cells. The theory of each is derived and various experimental measurements are discussed. (M.O.W.)

**653** OPTIMUM MAGNETS FOR MHD GENERATORS. Barthelemy, Robert R.; Oberly, Charles E. (Wright-Patterson AFB, Ohio). 14p. (CONF-651149-1). ORAU. Gmelin, AED-CONF-65-462-4.

From American Physical Society, Ohio Section, Fall Meeting, Dayton, Ohio.

The performance of combustion-driven MHD generators, operating with various types of magnets over a wide range of power output characteristics is examined. The results are used to determine, on the basis of either cost or weight, the most suitable type of magnet for a system at any given power level. It is concluded that an MHD power generation system can utilize a liquid-hydrogen-cooled aluminum magnet to effect both a cost and weight reduction for the total system over a wide range of applications. (J.H.M.)

**654** EXPERIMENTAL EVALUATION OF MHD GENERATORS OPERATING AT HIGH HALL COEFFICIENTS. Barthelemy, Robert R.; Stephan, Brian G.; Cooper, Robert F. (Wright-Patterson AFB, Ohio). 6p. (CONF-651149-2). ORAU.

From American Physical Society, Ohio Section, Fall Meeting, Dayton, Ohio.

The desirability of obtaining a two-terminal or single-circuit output from open-cycle MHD power generation systems leads to a consideration of three specific types of generator systems: continuous-electrode Faraday generators, Hall generators, and series-connected or diagonal-walled generators. Experimental data on two-terminal open-cycle MHD generators are extended into the range where the Hall effect is dominant. Operation of each type of generator is investigated under various gas, magnetic field, and generator conditions at Hall parameters of four and above. (W.D.M.)

**655** IMPROVEMENTS IN OR RELATING TO MAGNETOHYDRODYNAMIC ELECTRICAL GENERATOR SYSTEMS. Horn, George; Chojnowski, Boguslaw (to Central Electricity Generating Board). British Patent 1,048,304. Nov. 16, 1966. Filed Apr. 28, 1964.

A magnetohydrodynamic electrical generator system operating on an open cycle with fuel burned in combustion air to provide combustion gases which are passed through an MHD duct is described. There are provided: (1) a compressor for compressing air and passing it through a heat exchanger in the outlet gas flow from the MHD duct for first-stage preheating, and, (2) an independently fired

pre-heater for second-stage preheating of the compressed air whereby compressed air is provided as combustion air. Other design characteristics are discussed, and a drawing of the MHD generator is included. (J.H.M.)

## Fluid Physics

*Refer also to abstracts 551 and 809.*

**656** (AD–628917) GASDYNAMIC METHODS IN MHD FLOW. Summary Report No. 2, January 1, 1963–December 31, 1965. Cap, Ferdinand; Kerer, G.; Herrnegger, F.; Lackner, K.; Skarics, R. (Innsbruck Univ. (Austria). Institut fuer Theoretische Physik). Jan. 3, 1966. Contract AF 61(052)-675. 22p. (AFOSR–66-0405). CFSTI $2.60 cy, $0.50 mn.

A brief analysis is presented of the following items: (a) two-dimensional steady flow (variational method), (b) one-dimensional unsteady flow (variational method), (c) plasma with finite conductivity (exact solutions), (d) approximate solutions and linearized equations, (e) new numerical methods, (f) low-conductivity plasma, (g) applications, (h) and plasma acceleration and MHD power generation. A detailed discussion of future plans is given. (auth)

**657** (AD–630632) A NUMERICAL METHOD FOR SOLVING THE ONE-DIMENSIONAL UNSTEADY MGD BASIC EQUATIONS FOR FINITE MAGNETIC REYNOLDS NUMBER. Friedel, Helmut (Innsbruck Univ. (Austria). Institut fuer Theoretische Physik). July 3, 1965. Contract AF 61(052)-675. 20p. (AFOSR–66-0348). CFSTI $1.00 cy, $0.50 mn.

A numerical method based on the theory of characteristics for solving the parabolically degenerated one-dimensional unsteady MGD basic equations is described. Convergence and stability of the numerical method are analyzed in detail. (auth)

**658** (AD–633026) TABULATED SOLUTIONS OF THE EQUATION GOVERNING MAGNETOHYDRODYNAMIC FLOW WITH ALIGNED VELOCITY AND MAGNETIC FIELDS. Berger, S.; Genensky, S.; Madansky, A.; Ryan, M. (RAND Corp., Santa Monica, Calif.). Apr. 1966. Contract SD-79. 49p. (RM–4847-ARPA). CFSTI $2.00 cy, $0.50 mn.

When an infinitely conducting gas flows in a plane in such a way that the velocity and magnetic fields are everywhere aligned, then the governing magnetohydrodynamic equations may be linearized by transforming to the hodograph plane. The problem may then be reduced to the solution of a second-order linear partial differential equation for the stream function. Tabulated numerical solutions are presented for this equation. (auth)

**659** (AD–633027) OUTFLOW OF A CONDUCTING GAS JET WITH ALIGNED MAGNETIC FIELD FROM A RECTANGULAR CHANNEL. Berger, S. A. (RAND Corp., Santa Monica, Calif.). Apr. 1966. 43p. (RM–4884-ARPA). CFSTI $1.00 cy, $0.50 mn.

The MHD equations governing the two-dimensional flow of an infinitely conducting gas with aligned velocity and magnetic fields can be linearized by transformation to the hodograph plane. In an earlier RAND Memorandum these equations were solved for the flow of a jet through an orifice in a rectangular channel of finite width. The equation for the coefficient of contraction of the jet contains an infinite series, the terms of which depend on the solution of a second order linear ordinary differential equation. This differential equation was solved for a number of magnetic field strengths, allowing the value of the coefficient of contraction to be computed for various values of the basic parameters of the flow. (M.O.W.)

**660** (AD–634253) MAGNETOHYDRODYNAMIC PROPULSION. Friedel, H.; Lackner, K. (Innsbruck Univ. (Austria). Institut fuer Theoretische Physik). Dec. 5, 1965. Contract AF 61(052)-675. 33p. (AFOSR–66-0942). CFSTI $2.00 cy, $0.50 mn.

The applicability of magnetogasdynamic concepts to the description of the flow in plasma accelerators is studied. Two methods are proposed for the theoretical treatment of steady crossed-field and travelling-wave accelerators. (auth)

**661** (AD–634767) NONEQUILIBRIUM EFFECTS ON ENERGY TRANSFER IN AN IONIZED FLUID FLOW. Final Report. Powers, John O. (Naval Ordnance Lab., White Oak, Md.). Apr. 11, 1966. 131p. (NOLTR–66-59). CFSTI $4.00 cy, $1.00 mn.

A multi-fluid theory is formulated and the resulting equation system is developed and then applied to an ionized fluid flow situation in order to evaluate the mechanisms of energy transfer. The effects of temperature and compositional nonequilibrium were explored for several temperature levels and for a range of fluid flow velocities. Comparisons of the multi-fluid theory results are made with results from conventional single-fluid theory for approximately equivalent fluid flow conditions. The multi-fluid theory investigations produced results which were generally consistent with the single-fluid theory procedures. The multi-fluid results were useful in evaluating the relative importance of the several different energy transfer mechanisms. In particular, it was demonstrated that conditions which yield electron temperatures greater than the heavy particle temperature led to a reduction in total heat transfer with increased electron temperature. (auth)

**662** EXPLANATION OF STELLAR AND PLANETARY MAGNETIC FIELDS BY A TURBULENCE-CAUSED DYNAMO MECHANISM. Steenbeck, M.; Krause, F. (Institut fuer Magnetohydrodynamik, Jena, Ger.). Z. Naturforsch., 21a: 1285-96(Aug. 1966). (In German).

The effects of a turbulent motion on magnetic fields have been investigated. Especially, turbulence was treated under the influence of Coriolis forces and gradients of density and/or turbulence intensity. It was shown that on these conditions the average cross product of velocity and magnetic field has a nonvanishing component parallel to the average magnetic field. Here the consequences of this effect for rotating, electrically conducting spheres are given. At first a sphere rotating with constant angular velocity is investigated. The quadratic effect provides for dynamo maintenance of the magnetic fields. A field of dipole-type has the weakest condition for maintenance. Applications to the magnetic field of the earth show a good agreement with the conceptions of the physical state of the earth's core. For a second model differential rotation is included. We have also dynamo maintenance. Since one must assume that generally the angular velocity is a function decreasing with the distance from the center of the sphere, the calculations show that there is a preferred self-excited buildup of a quadrupole-type field. This model may be applicable to magnetic stars. Finally we look for dynamo maintenance of alternating fields. The skin depth is considered to be small compared with the radius of the sphere, then we have plane geometry. The existence of periodical solutions is proved. Applications to the general magnetic field of the sun, which has a period of 22 years, are discussed. (auth)

**663** COMPOSITE METALLIC AND DIELECTRIC INSULATORS FOR HIGH CURRENT ARC ELECTRODES. Rohatgi, V.; Aisenberg, S. (Space Sciences, Inc., Waltham, Mass.). Rev. Sci. Instrum., 37: 1603-4(Nov. 1966).

A method that has been used to extend the operating life of insulating structures associated with high current electrodes in magnetically accelerated arcs is described. The concept involves the use of electrically floating metallic shields plus thin insulating layers to reduce the insulator erosion usually associated with high current arcs. This solution can probably be applied to many high current arc systems. (auth)

**664** CALCULATION OF PONDEROMOTIVE FORCES ACTING ON A CONDUCTING CYLINDER IN THE TRAVELING MAGNETIC FIELD OF A CYLINDRICAL INDUCTOR. Krumin, Yu. K. (Inst. of Physics, Riga).

Latv. PSR Zinat. Akad. Vestis, Fiz. Teh. Zinat. Ser., No. 2, 107-16(1966). (In Russian).

A description is given of a method for determining ponderomotive forces acting on hollow and solid conducting cylinders situated in the traveling magnetic field of a cylindrical inductor. Graphs are plotted and formulas are derived that permit practical calculations of the ponderomagnetic forces. (IAA)

**665** GEOMETRY OF STREAMLINES IN HYDROMAGNETIC FLUID FLOWS WHEN THE MAGNETIC FIELD IS ALONG A FIXED DIRECTION. Krzywoblocki, M. Z. v.; (Michigan State Univ., East Lansing). Proc. Amer. Math. Soc., 17: 608-10(1966).

The report of Suryanarayan with the same title (Proc. Amer. Math. Soc., 16: 90-6(1965)) is referred to wherein three-dimensional steady flows of inviscid magnetic fluids is discussed. The assumption is that the magnetic field is along a fixed direction and the main goal is to investigate various dynamical and kinematical relations connecting the characteristic properties of the flow and the field quantities with the geometrical parameters of the streamlines. Expressions were derived for the tangent, principal normal, and binormal vectors, the curvature and torsion of the streamlines in terms of the velocity components, of the pressure, density of the medium, and of the intensity of the magnetic field. Variations were obtained for the hydromagnetic pressure along streamlines, along principal normals to the streamlines and it was shown that this pressure remains constant along the binormals. It was found that Bernoulli surfaces exist in the case of incompressible fluid and that they form the surfaces on which the sum of the fluid pressure, kinetic energy, and magnetic energy is constant. For an isentropic flow, the variation of the fluid pressure along the streamline is expressed in terms of the Mach number, the magnetic field intensity, the fluid density and the magnitude of the fluid velocity. Suryanarayan made a tacit assumption that the medium in question possesses the electrical resistivity equal to zero or the electrical conductivity equal to infinity. On one side this assumption results in a very idealistic case, on the other it results in a significant simplification of the equations of continuity, motion, and of Maxwell's equations of fields. It is shown that this tacit assumption is superfluous and the technique of Suryanarayan is applicable to a more general case with a finite magnitude of the electrical resistivity. (BBB)

**666** DIFFRACTION AND REFLECTION OF A SHOCK WAVE AT THE BOUNDARY OF TWO VARYING DENSITY MEDIA. Fradkin, E. S. Tr. Fiz. Inst., Akad. Nauk SSSR, 29: 257-78(1965). (In Russian).

The problem of the reflection of a shock wave was studied in a coordinate system in which the point of intersection of the shock-wave front was at rest, resulting in a stationary condition. The calculations indicated that if the angle of incidence of the wave was smaller than a certain critical angle, the wave is subjected to the laws of ordinary reflection; under normal incidence on the wall, the pressure created is higher than that of the unperturbed medium. Beyond the critical angle, no regular reflection takes place but a fork-shaped triple-wave configuration is obtained. The cases examined included passage of the shock wave from the lower into the higher-density medium and the inverse case. Depending on the angle of incidence with respect of the critical angle, regular or fork-shaped configurations are encountered. (TTT)

**667** CONTINUUM FEEDBACK CONTROL OF INSTABILITIES ON AN INFINITE FLUID INTERFACE. Melcher, James R. (Massachusetts Inst. of Tech., Cambridge). Phys. Fluids, 9: 1973-82(Oct. 1966).

Field-coupled Rayleigh–Taylor instabilities on a fluid interface can be suppressed by means of feedback. Deflections of the interface are detected to provide a signal which is amplified and fed back to a structure coupled to the interface through the fields. A theoretical study is given of the conditions for stability of an infinite interface coupled to an active structure through a perpendicular electric field and a tangential magnetic field. In both cases the interface is assumed to be perfectly conducting. A traveling-wave-train analysis is used to show the regimes of stability as they depend on the Taylor wavelength, electric or magnetic pressure, feedback gain, and technique of sampling interface deflections. Emphasis is given to the effect of feedback derived from detecting surface deflections averaged over a sampling area and feeding back to that same area. (auth)

**668** SUDDENLY PRESSURIZED ELASTOMAGNETOHYDRODYNAMIC CHANNEL FLOW. Farn, Charles L. S.; Arpaci, Vedat S. (Univ. of Michigan, Ann Arbor). Phys. Fluids, 9: 1970-3(Oct. 1966).

The channel flow of a suddenly pressurized viscoelastic and electrically conducting fluid under the influence of a constant and transversal magnetic field is given analytic treatment. Flow oscillations resulting from the elasticity of the fluid and damping effect of the magnetic field on these oscillations are shown in terms of three parameters. (auth)

**669** STABILITY OF MAGNETOHYDRODYNAMIC HALF-JET. PART I. MAGNETOHYDRODYNAMIC HALF-JET. Lessen, Martin; Deshpande, Narayan V. (Univ. of Rochester, N. Y.). Phys. Fluids, 9: 1960-4(Oct. 1966).

A boundary-layer-type theory for a compressible half-jet with an aligned magnetic field is formulated. The electrical conductivity of the fluid is assumed to be infinite. It is known in the incompressible case that for a meaningful solution the ratio of the magnetic pressure and the dynamic pressure cannot exceed unity. The ratio has a further limitation in the compressible case. (auth)

**670** STABILITY OF MAGNETOHYDRODYNAMIC HALF-JET. PART II. INVISCID STABILITY OF INCOMPRESSIBLE MAGNETOHYDRODYNAMIC HALF-JET. Lessen, Martin; Deshpande, Narayan V. (Univ. of Rochester, N. Y.). Phys. Fluids, 9: 1965-9(Oct. 1966).

Inviscid stability of an incompressible half-jet in the presence of an aligned magnetic field was investigated, and the neutrally stable eigenvalues are determined. It is shown that the magnetic field has a stabilizing effect on this boundary-layer type flow, but it does not stabilize the flow completely. (auth)

**671** PROCEEDINGS OF FIFTH SYMPOSIUM ON THE ENGINEERING ASPECTS OF MAGNETOHYDRODYNAMICS, SPONSORED BY MASSACHUSETTS INSTITUTE OF TECHNOLOGY, APRIL 1-2, 1964. 313p. (CONF-542).

Thirty-four papers on various engineering aspects of MHD research are included. Separate abstracts for these papers may be found in the report number index as CONF-542. (M.O.W.)

**672** MULTIDISCIPLINARY ASPECTS OF MAGNETOGASDYNAMICS. Cambel, Ali Bulent (Northwestern Univ., Evanston, Ill.). 31p. (CONF-660629–2). ORAU. Gmelin, AED-CONF-66-171-2.

From 5th National Congress of Applied Mechanics Meeting, Minneapolis.

Discussions are presented of problems wherein the velocity field of a conducting fluid interacts with electromagnetic fields or when charged particles constituting a fluid experience electromagnetic effects. Particular attention is given to application in high-speed flows as may be encountered in electric propulsion, magnetogasdynamic power generation, and certain approaches to reentry phenomena. (J.H.M.)

## Geophysics

**673** (AD–629430) IONOSPHERIC RESEARCH. Quarterly Progress Report No. 8, July 1, 1965–September 30, 1965. Webb, H. D. (Illinois Univ., Urbana. Electrical Engineering Research Lab.). Contract DA-36-039-AMC-03703 (E). 47p. CFSTI $4.60 cy, $0.50 mn.

Moon reflected signals were received for 360 hours or 39 days at 150.60 Mc, and for 38 days at 413.25 Mc. The

n × 180 degrees ambiguity can probably be resolved on all of the days. A program has been written for using the California Computer Products plotter, which can be programmed to draw grid lines, label coordinates and write captions as well as plot curves. This plotter is to be used for the Faraday rotation angle and electron content plotting. The 150.6-Mc receiver is being converted into a phase-locked receiver which will automatically stay tuned to the incoming signal. A biconical spiral antenna for receiving circular polarization at 150.6 Mc has been built and tested. Some modifications are required before the antenna can be made operational. A thesis dealing with electron and ion temperature measurements for October 1964, is appended. (auth)

**674** (AD–629449) IONOSPHERIC RESEARCH. Quarterly Progress Report No. 9, October 1, 1965–December 31, 1965. Webb, H. D. (Illinois Univ., Urbana. Electrical Engineering Research Lab.). Contract DA-36-039-AMC-03703 (E). 18p. CFSTI $1.60 cy, $0.50 mn.

Moon-reflected signals at 150.6 Mc were received on 34 days for a total of approximately 252 hours. Moon-reflected signals at 413.25 Mc were received on all of these days. The Faraday rotation angles have been read from the strip charts obtained at the two frequencies. The data at 413.25 Mc are used to resolve the nx 180 degrees ambiguity in the 150.6 Mc data. Calculations of electron content have been completed for the observations through November 3, 1965. The California Computer Products plotter has been used to plot the Faraday rotation and electron content values for all of the data from July 1961 through 1964 and for some of the 1965 data. An atlas of Faraday-rotation and electron-content data for July 1961 through 1964 is being prepared under contract AMC 01710 (E). The data have been machine plotted and the graph sheets are being prepared. A phase lock receiver has been designed and built for use in keeping the 150.6 Mc receiver "on signal." Two biconical, spiral, circularly polarized antennas have been designed, built and tested. These antennas were designed for use in measuring the depolarization at the surface of the moon. (auth)

**675** (AD–630591) ANTENNA IMPEDANCE PROBES IN HIGHLY DISTURBED IONOSPHERES. Final Report, June 1–September 30, 1965. Seljaas, Karl G. (Utah Univ., Salt Lake City. Upper Air Research Lab.). Contract AF 19(628)-5192. 47p. (UU–66-2; AFCRL–65-737). CFSTI $2.00 cy, $0.50 mn.

Instrumentation developed for measurement of electron densities in a highly disturbed ionosphere is reported. The measurement determines by a standing wave technique, the RF impedance of thin cylindrical antennas immersed in the plasma of the ionosphere. The electron density can be deduced from the antenna impedance variations. A previously developed Standing Wave Impedance Probe was used at frequencies of 3 and 12 MHz in conjunction with a newly developed 300-MHz system. Instrumentation details including schematic diagrams of both systems are presented. The dual impedance probe system was included in the payload of an Honest John-Nike-Javelin III fired from Eglin AFB in a DASA Project 6.4 certification round. (auth)

**676** (AD–632164) INTERPRETATION OF THE FIRST-ORDER CORRECTION TO THE MAGNETIC MOMENT INVARIANT. Ball, R. H. (RAND Corp., Santa Monica, Calif.). Apr. 1966. 5p. (P–3350(RAND)). CFSTI $1.10 cy, $0.50 mn.

In the study of the permanence and stability of the Van Allen radiation belts and in studies of mirror machines, it is of particular importance to understand the nature and behavior of the adiabatic invariants of the particle motion. It is shown that the first-order correction to the "magnetic moment" M or "first adiabatic invariant" has a simple physical interpretation, and two simple expressions are shown for it. (TAB)

**677** (AD–632266) A STUDY OF WAVE PARTICLE INTERACTIONS IN THE MAGNETOSPHERE AND A COMPLEMENTARY STUDY OF THE PROPAGATION CHARACTERISTICS OF WHISTLERS AND RELATED PHENOMENA. Final Report. Helliwell, R. A. (Stanford Univ., Calif. Stanford Electronics Labs.). Mar. 1966. Contract AF-AFOSR-783-65. 13p. (AFOSR–66-0715). CFSTI $1.00 cy, $0.50 mn.

Three principal areas of investigation are reviewed: (1) propagation and detection studies at vlf, (2) basic studies of the thermal plasma in the magnetosphere, and (3) wave–particle interactions. In most cases only a brief description is given, particularly where details are available in reports and publications listed in the attached bibliography. In addition to the bibliography, there is included a list of papers presented at technical meetings and symposiums. (auth)

**678** (AD–633251) ELECTRIC FIELDS IN THE MAGNETOSPHERE. Scientific Report No. 269. Dungey, James W. (Pennsylvania State Univ., University Park. Ionosphere Research Lab.). Apr. 10, 1966. Contract AF 19(628)-4014. 15p. (AFCRL–66-300). CFSTI $1.00 cy, $0.50 mn.

The first approximation corresponds to perfect conductivity and relates to the DS circulation. The component E11 parallel to B must be controlled by charge neutrality and the interaction with low energy particles is most important. Electrons move fast compared to the characteristic time of the field and approximations can be used, but not for protons. Sudden changes in the situation occur at reconnection. In the tail the discussion concerns interdiffusion of plasma between the magnetosphere and the solar wind. The possibility of a large E11 being set up occurs only at the tail reconnection. The low electron density in the magnetosphere is still puzzling. (auth)

**679** (AD–633302) EFFECT OF TEMPERATURE CHANGES ON THE ELECTRON DENSITY DISTRIBUTION IN THE F2-REGION OF THE IONOSPHERE. PART II. Scientific Report No. 270. Somayajulu, Y. V. (Pennsylvania State Univ., University Park. Ionosphere Research Lab.). Apr. 20, 1966. Contract AF 19(628)-4014. 24p. (AFCRL–66-313). CFSTI $1.00 cy, $0.50 mn.

The problem of changes in the F2-region electron density distribution caused by changes in the neutral gas temperature is investigated using an analytical representation of the equilibrium quiet-day electron density distribution under the influence of production, loss and diffusion. Using the currently accepted temperature dependences of these quantities, it is concluded that the change caused in $N_m F2$ is small and that under certain conditions $N_m F2$ may increase or decrease. The main effect of temperature, under these conditions, is to increase the thickness of the F2 region; in agreement with observation. It is also shown that to explain the large reduction in $N_m F2$ in midlatitudes during storms, the loss rate has to be quite sensitive to temperature. (auth)

**680** (AD–634358) NEGATIVE ION DETECTION IN THE IONOSPHERE FROM EFFECTS ON ELF WAVES. Research Report, July 1965–March 1966. Shawhan, Stanley D. (Iowa Univ., Iowa City. Dept. of Physics and Astronomy). Contracts Nonr-1509(06); N9onr-93803. 54p. CFSTI $3.00 cy, $0.50 mn.

The theory for propagation of small amplitude electromagnetic waves in a cold, homogeneous plasma including negative ions and immersed in a uniform, static magnetic field is developed. It is found that for longitudinal propagation each negative ion introduces a resonance at the negative ion gyrofrequency, a concentration dependent cutoff frequency above the negative ion gyrofrequency, and possibly a crossover frequency depending on the ion concentrations and charge to mass ratios. At both the gyrofrequency and the cutoff frequency the group refractive index becomes infinite. Between these two frequencies there is a "nose" frequency for which the group refractive index is a minimum. Examples are given for a three and five component plasma. Application of this negative ion theory is made to propagation of negative ion whistlers in the ionosphere. It is found that for frequencies near the neg-

ative ion gyrofrequencies the WKB approximation is valid above 300 km during the nighttime and 150 km during the daytime. Effects of collisions can be neglected above 150 km. An ideal experiment is proposed for observation of negative ion whistlers (1–1000 cps). Sample whistler, frequency-time spectrograms like those which would be observed with such an experiment, are sketched. From the distinctive frequencies on these sample spectrograms, it is shown that the negative ion specie and concentration can be determined using the developed cold plasma expressions. (auth)

**681** (AD–634359) THE TEMPORAL VARIATIONS OF ELECTRON INTENSITIES AT LOW ALTITUDES IN THE OUTER RADIATION ZONE AS OBSERVED WITH SATELLITE INJUN 3. Progress Report. Craven, John D. (Iowa Univ., Iowa City. Dept. of Physics and Astronomy). Apr. 1966. Contracts Nonr-1509(06); N9onr-93803. 75p. CFSTI $3.00 cy, $0.75 mn.

Temporal variations of the intensities of electrons (E > 40 keV, > 230 keV, > 1.6 MeV) trapped in the outer radiation zone in the region 3.0 < or L < or 6.0 and mirroring at altitudes of approximately 1500 km were studied during a seven-month period from January 1 to July 31, 1963, by means of three Geiger-Mueller tubes on-board the U. of Iowa/Office of Naval Research research satellite Injun 3. From observations during some twenty geomagnetically disturbed periods, it is shown that the largest intensity variations occur at the onset of such disturbances and that subsequent behavior is dependent on the magnitudes of the disturbances as measured by the maximum daily sums of the planetary magnetic disturbance parameter, $K_p$. The time histories of these intensity variations are compared with those of 3-hour averages of the horizontal component of the geomagnetic field at College, Alaska (L = 5.5), for several disturbed periods. (auth)

**682** (AD–634841) IONOSPHERIC VARIATIONS OVER WASHINGTON, D. C., BEFORE AND AFTER GEOMAGNETIC STORMS. Research and Development Report, June 1963–January 1966. Noonkester, V. R. (Navy Electronics Lab., San Diego, Calif.). Mar. 25, 1966. 20p. (NEL–1367). CFSTI $1.00 cy, $0.50 mn.

Midday averages of the critical frequencies of ordinary waves of the F2 and E regions, $F_0F2$ and $F_0E$, and the minimum virtual height of the E region, hE, were computed from hourly values to represent the E and F regions at Washington, D. C. Long-term variations were removed by mathematical filtering. Superposed epoch analysis of the filtered averages revealed that: (1) h and fE are not related to magnetic storms, (2) except during sunspot minimum, fF is large 1 or 2 days before magnetic storms and and small up to 3 days afterwards, (3) during sunspot minimum fF is not related to magnetic storms. (auth)

**683** (AD–635212) MODAL SOLUTION OF A POINT SOURCE IN A STRONGLY FOCUSING MEDIUM. Scientific Report No. 2. Yaghjian, Arthur D.; Kornhauser, Edward T. (Brown Univ., Providence, R. I. Div. of Engineering). June 1966. Contract AF19(628)-5846. 19p. (AFCRL–66-403). CFSTI $1.00 cy, $0.50 mn.

The ray solution of a point source located in a medium with varying propagation constant given by $k(z) = k_0\sqrt{\operatorname{sech}^2\alpha z - \beta^2}$ exhibits for $\beta = 0$ the interesting property of the focusing of all rays at periodic distances. The problem of finding the exact solution for the electromagnetic field reduces to that of finding Green's function to the scalar wave equation, $\nabla^2 G + k_0^2(\operatorname{sech}^2\alpha z - \beta^2)G = [\delta(r)\delta(z - z_0)]/2\pi r$. The eigenfunctions for this equation consist of a mixed spectrum, i.e., a continuous set of eigenfunctions plus a finite number of discrete eigenfunctions. The mixed spectrum is normalized and shown to form a complete set, in which the Green's function is expanded. Examination of the discrete spectrum in the far field reveals that all the lower order modes add in phase where ray theory predicts focusing. Integral approximations for the continuous spectrum shows that it represents a non-propagating, rapidly decaying field, which is negligible compared to the discrete spectrum, except in the region "close" to the point source. (auth)

**684** (AD–635285) GROUND-LEVEL MAGNETIC FLUCTUATIONS DUE TO HIGH-ALTITUDE NUCLEAR BURSTS OR IMPULSE SOURCES OF NATURAL ORIGIN. Field, E. C.; Greifinger, C. (RAND Corp., Santa Monica, Calif.). May 1966. Contract SD-79. 42p. (RM–4946-ARPA). CFSTI $2.00 cy, $0.50 mn.

The response of the ionosphere-exosphere system to a bomb-like hydromagnetic source and the resultant time-dependent ground-level magnetic fluctuations are examined theoretically, with emphasis placed upon gaining an understanding of the time behavior of the ground-level signal. The methods of calculation are also applicable to certain magnetic fluctuations of natural origin. An analytic treatment is used, whereby the problem is reduced essentially to finding the poles and residues of previously derived hydromagnetic transmission coefficients. Conditions corresponding to high magnetic latitudes are used, but some conclusions corresponding to more general conditions are drawn. Bomb-induced ground-level magnetic fluctuations are interpreted in terms of a broadband excitation of ionospheric and exospheric resonant oscillations. Even for broadband sources which excite all of the many resonances, the signal rapidly becomes dominated by the lowest characteristic frequencies. Thus, for a wide range of source functions, the frequency content of the transmitted signal would be determined largely by the resonant properties of the propagation medium. Two examples of this are the magnetic fluctuations measured after the Argus and Starfish high-altitude nuclear tests. For hypothetical high-latitude bursts detonated in or above the lower ionosphere, the ground-level signal is predicted to be nearly left-hand circularly polarized in the daytime and to exhibit nearly the polarization of the source at night. For many situations of practical interest, the enhancement of the lower ionospheric ionization density by bomb x rays is a very important consideration. (auth)

**685** (AD–635380) ON THE RELATION OF IONOSPHERIC DOPPLER SHIFT, PHASE VELOCITY, AND INTEGRATED ELECTRON CONTENT. Arendt, P. R. (Army Electronics Command, Fort Monmouth, N. J.). June 1966. 34p. (ECOM–2724). CFSTI $2.00 cy, $0.50 mn.

Difficulties are discussed which are inherent with unlimited use of the differential Doppler method for satellite measurements. For precision, restriction is recommended to overhead passages and to closely related frequencies. The restriction applies to measurements of the ionospheric electron content, finding of geodetic positions, and to hybrid methods combining polarization and frequency measurements. (auth)

**686** (AD–640991) ANALYSIS OF LOW-LATITUDE D AND E REGION DATA. Semi-Annual Technical Report, November 15, 1965–May 15, 1966. Sears, Robert D. (IIT Research Inst., Chicago). Sept. 1966. Contract N00014-66-C0030. 55p. (T-6142). CFSTI $3.00 cy, $0.50 mn.

Analyses of ionograms, high-frequency phase and amplitude data and riometer measurements of absorption which will lead to a better determination of the D- and E-region electron density profile for low-latitude regions are described. True-height analyses of sample ionograms allow determination of the contribution of the F region to 30-MHz absorption as determined from the riometer data. The topside F region is fit by a Chapman layer and F-region temperature effects are qualitatively considered to show that the computed absorption from the F region tends to be a maximum estimate for that region. The computation of diurnal absorption variation from the 30-MHz riometer data requires that the cosmic-noise power which would be received in the absence of absorption be computed. A program which has been developed to predict the cosmic-noise diurnal variation given a particular site and antenna pattern has been improved and the results to date are de-

scribed. The separation of E- and F-region reflection modes by comparison of the phase data with ionogram virtual group paths for the same frequencies shows that the different modes can be separated in the data with little ambiguity. Theory which forms the basis of the analysis of phase, amplitude, group path, and absorption data is summarized and two sample analyses are performed to show the sensitivity of the Faraday fading data to small changes in electron content along the signal path. The group and phase data are compared with the amplitude results to show their relationship and the means of identifying the height of variation of electron content along a propagation path. (auth)

**687** (N-66-22228) ELECTRON ACCELERATION IN THE TRANSITION REGION BEHIND THE EARTH'S BOW SHOCK. Webster, David L. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). 1964. 22p. (NASA-TM-X-56197). CFSTI $1.00 cy, $0.50 mn.

The highly disordered field found by Pioneer I in the transition suggests a possible explanation for the "spikes" of high-energy electrons found by later satellites. Such a field must develop a great variety of local space–time patterns. If an effective field pattern develops in the transition region, some of the electrons already in the high-energy tail of the velocity distribution may be accelerated to very much higher energies, and then they may escape from the pattern before reversed induction can take energy away from them. After escape, they may make further gains of energy by Fermi accelerations and related mechanisms. Thus they should spread over a wide part of the transition region, some of them even going out through the bow shock or into the magnetosphere; and if a spike found by any satellite is ascribed to such electrons, the field pattern in which they started to gain high energy was not necessarily very near that satellite. (auth)

**688** (N-66-22936) SIGNIFICANT ACHIEVEMENTS IN IONOSPHERES AND RADIO PHYSICS, 1958–1964. Schmerling, E. R. (National Aeronautics and Space Administration, Washington, D. C.). 1966. 68p. (NASA-SP-95). GPO $0.45.

The major areas of progress in ionospheric research over the years 1958 to 1964 are outlined. The plasma properties of the ionosphere are discussed with particular emphasis on the topside of the F-region. Also included are discussions of the collision dominated and photoequilibrium regions of the ionosphere as well as the protonosphere and very low frequency phenomena. In addition, various dynamic effects present in the ionosphere are examined, including electrodynamic drift, sporadic E, irregularities, and winds. (STAR)

**689** (N-66-23719) EXPERIMENTAL INVESTIGATIONS RELATED TO IONOSPHERIC PROBING. PART I. Final Report. Katzin, M.; Markey, W. P.; Ringwalt, D. L.; Skinner, R. E. (Electromagnetic Research Corp., College Park, Md.). Jan. 31, 1966. Contract NASw-835. 254p. (NASA-CR-74186). CFSTI $6.00 cy, $1.50 mn.

A program for D-region simulation by ultraviolet photoionization of nitric oxide was studied both theoretically and experimentally. During the theoretical studies, the required photon flux was calculated and it was found that electron densities suitable for D-region simulation could be generated. Additionally it was determined that a lower electron temperature should be obtainable with a krypton UV tube than with a hydrogen tube. During experimental investigations, several tubes were built and the effects of tube geometry and gas filling were considered. Krypton was found to yield a higher efficiency and output than hydrogen or hydrogen–neon combinations for the gas filling. A plasma of approximately the desired characteristics was generated by photoionization of NO in a bell jar, and ionization densities and electron temperatures of the expected order were obtained. For large volume low temperature plasma development, a UV tube design was chosen and the tubes were proven by life tests. (STAR)

**690** (N-66-23747) THE FERMI ACCELERATION OF CHARGED PARTICLES IN THE TRANSITION REGION BEYOND THE MAGNETOSPHERE. Shen, C. S.; Chang, C. C. (Catholic Univ. of America, Washington, D. C. Dept. of Space Science and Applied Physics). [1965]. 34p. (NASA-CR-74480; SSAP-65-007(Rev.)). CFSTI $2.00 cy, $0.50 mn.

Revised.

Recent experiments of IMP-I satellite show the existence of high energy electrons with $E \geq 30$ keV in the transition region between the shock and the magnetosphere. It is proposed that the electrons are locally accelerated by means of a Parker-Wentzel version of the Fermi mechanism. The trapping and acceleration dynamics of a typical electron along the distorted background magnetic field line is studied. It is found that the magnetic bottleneck just outside the shoulders of the magnetopause can reflect the gyrating electron toward upstream of the solar wind, while the large amplitude magnetohydrodynamic wave originated near the shock front can push the electron downstream. The electrons thus trapped gain about 3 to 4 times the energy before they can penetrate the advancing wave. Because of the scattering of small scale magnetic irregularities, a part of the penetrated electrons redistribute their pitch angle and can be trapped again by another advancing wave train. Thus the high energy electrons found in the IMP experiment can be built up by this process in the order of a few minutes. (auth)

**691** (NASA-CR-618) ANALYTIC AND COMPUTER STUDIES OF ELECTRON COLLECTION BY A SPHERICAL SATELLITE IN THE EARTH'S MAGNETIC FIELD. Parker, Lee W. (Mount Auburn Research Associates, Inc., Cambridge, Mass.). Oct. 1966. 79p. CFSTI $2.50 cy, $0.75 mn.

If an attempt is made to produce an artificial aurora by ejecting a beam of electrons from a satellite, the experiment will be jeopardized if the satellite potential becomes so high as to prevent the escape of the beam electrons. The buildup of potential depends on the current collection properties of the satellite. The theoretical problem considered is that of the collection of electrons by a spherical satellite in the earth's magnetic field, as a function of the satellite potential, the satellite dimensions, and the magnetic field strength. At low or intermediate positive satellite potentials, the collected current is of the order of the ambient thermal electron current collected by an area equal to twice the cross-sectional area of the satellite. At large potentials, the current rises slowly, and is proportional to $V^m$, where V is the potential, and m is less than unity. The value of m has been estimated theoretically in this work, by two methods. One of these methods, namely, drift approximation theory to second order, leads to an equation, involving the form of the potential distribution, from which the value of m can be found. If the potential distribution is assumed proportional to $r^{-n}$, where r is the radius in spherical coordinates, the value of m is found to be $2/(n + 2)$. In the other method, the integrals of the exact equations of motion are analyzed to obtain rigorous bounds on the current collected. The current is found to be bounded by a value proportional to $V^{\frac{1}{2}}$, independent of the form of the potential distribution under reasonably general conditions. At low potentials, the current may be calculated by solving a self-consistent Poisson problem in which the charge densities depend on the form of the potential distribution. Methods for performing this calculation are discussed. The accuracy and stability of the numerical solution of the Poisson problem are shown to depend on the position of the boundary at which the potential is assumed to be zero. (auth)

**692** (NP-16306) ELECTROMAGNETIC PULSE RESEARCH. Final Report, September 1, 1964–August 31, 1965. Inston, H. H.; Siddons, R. A. (IIT Research Inst., Chicago, Ill.). 83p. (T-1029-6).

Information is given on the electromagnetic pulse radiated by high altitude nuclear explosions. A method is included for calculating the electromagnetic fields from

high altitude bursts. A general description is given of the sources and forms of the electromagnetic pulse, with particular emphasis on the way its characteristics vary with height of burst. Information is also included on the vulnerability of electrical equipment to the electromagnetic pulse from a high field surface explosion and the variation of electromagnetic pulse with height of burst in the low altitude region. (J.H.M.)

**693** INFLUENCE OF SOLAR ACTIVITY ON THE TROPOSPHERE IN THE POLAR CAP REGIONS. Mustel, E. R. (Astronomical Council, Academy of Sciences, USSR). Soviet Astron.-AJ (Engl. Transl.), 10: 288-94 (Sept.-Oct. 1966).

Translated from Astron. Zh., 43: 365-73(Mar.-Apr. 1966).

The effect of quasi-stationary corpuscular streams on the surface air pressure in the earth's magnetic-cap regions is discussed. "Central" solar active regions (AR) responsible for geomagnetic disturbances whose commencement was relatively free from superposition of prior disturbances are employed. The pressure variations for Canadian island stations and Thule are nearly opposite in phase from the variations in the geomagnetic index $A_p$, while for the continental station Vostok the pressure and $A_p$ variations are approximately in phase. This behavior agrees with the differences between island and continental stations found for chromospheric flares. The effects on the polar-cap atmosphere of subrelativistic protons injected from chromospheric flares are studied further. Bailey's catalog of cases of polar-cap absorption of radio waves (PCA events) is used. The moment of PCA commencement is adopted as zero time for the curves of the superposed-epochs (SE) method. The results of applying the SE method to all PCA events for which meteorological data are available are illustrated. Curves represent the mean pressure for four Canadian island stations, the pressure for Thule, and for Vostok. Discussion indicates, in particular, that the maximum $\alpha$ in the SE curves is apparently associated with sporadic geomagnetic disturbances. (auth)

**694** THE DISTRIBUTION OF SOLAR-TROPOSPHERIC DISTURBANCES OVER THE EARTH'S SURFACE. Kubyshkin, V. V. (Volgograd Pedagogical Inst.). Soviet Astron.-AJ (Engl. Transl.), 10: 295-303(Sept.-Oct. 1966).

Translated from Astron. Zh., 43: 374-84(Mar.-Apr. 1966).

The manner in which solar-tropospheric disturbances are distributed over the globe was investigated. The list of 41 chromospheric flares used previously is again employed. The previous material is here supplemented by records of many other weather stations. Figures show the superposed epochs (SE) curves. The ordinate is the surface air pressure in millibars, and the date of appearance of a flare is adopted as zero time. Curves represent mean values for the stations of each group. Analysis of these curves and similar SE curves derived previously indicates the following. Rises in surface pressure ($\Delta p > 0$) approximately synchronous (at phase $\Delta t \approx +4^d$) with the geomagnetic disturbances usually occur above the continents; the amplitude increases with station latitude. The maximum in $\Delta p$ at phase $\Delta t \approx +4^d$ is gradually replaced by a minimum with approach to the Atlantic Ocean. A pressure minimum is also observed at coastal and island stations in the Soviet Arctic. Evidently a pressure drop during periods of maximum geomagnetic disturbance from flares is more typical of oceanic and coastal regions. These findings agree with many previous studies. The results for the Scandinavian peninsula, and certain other circumstances are apparently associated with the general laws of atmospheric circulation. (auth)

**695** ACOUSTIC GRAVITY WAVES CAUSED BY THE NUCLEAR EXPLOSION ON OCTOBER 30th, 1961. Kohl, Harry (Max-Planck-Institut fuer Aeronomie, Lindau, Ger.). pp 160-9 of Proceedings of NATO Advanced Study Institute, Skeikampen, Norway, April 17-26, 1963. Amsterdam, North-Holland Publishing Co., 1964.

After the ~50-Mt nuclear explosion on October 30th, 1961, at Novaya Zemlya (USSR) periodical disturbances of the ionospheric F layer were recorded by a number of stations. The critical frequencies ($f_0$) of the F layer at Lindau are shown for this day. Between 1000 and 1030 UT $f_0F2$ increased rapidly. At 1030 UT the electron density at the layer max had more than doubled compared with that at 1000 UT. Afterwards the critical frequency dropped in an oscillatory manner, showing 4 maxima at intervals of $1\frac{1}{2}$ hr. Since the ionograms were only taken every half hour, some details of the disturbance were missed. Several other stations which recorded ionograms more frequently reported a short, marked decrease in the critical frequency at the beginning of the disturbance. Some $f_0^2$ vs height (h) profiles are shown. At 1030 UT the layer had moved down and become thin, while the critical frequency was high. At 1100 UT the layer was even lower. Analysis of data collected from different stations show that the disturbance was propagated with a velocity of 630 m/sec, and that the period of the oscillation of the critical frequency became longer with increasing distance from the location of the explosion. The observations described, especially the $f_0F2$ curves, suggest that the disturbance was caused by a propagating wave. The wave was probably a gravity wave rather than a sound wave. It was shown, with simplifying assumptions, that a mechanical pulse in the atmosphere may release a spectrum of acoustic gravity waves traveling with dispersion in such a manner that periodic disturbances in the F region result. As a further consequence of dispersion, the period of the wave increases with increasing distance from the source. This model was applied to the observations of disturbances in the F region after the nuclear explosion. Satisfactory agreement was obtained by selecting an adequate dispersion curve. (BBB)

**696** EVOLUTION OF THE OCCURRENCE OF RADIOELECTRIC WHISTLERS BETWEEN THE MAXIMUM AND THE MINIMUM OF SOLAR ACTIVITY. Corcuff, Yvonne; Corcuff, Pierre; Tixier, Michel (Paris Univ., Vienne, France). Compt. Rend., Ser. B, 263: 584-7 (Aug. 22, 1966). (In French).

Although essentially the occurrence of whistlers is observed at night during the maximum of solar activity (October 1957–October 1959), the occurrence of whistlers is also notable during the day at solar minimum (1964–1965). Two pronounced maxima exist, one at the end of the afternoon; the other, at the beginning of morning. These facts, which are clearer the lower the latitude of the receptor, are interpreted. The variation in the numbers of whistlers received at night during the solar cycle are also studied. (G.O.Y.)

**697** COMPARISON OF ELECTRON TEMPERATURE WITH THERMOSPHERE PROBE DATA. Singh, R. N.; Tolpadi, S. K. (Banaras Hindu Univ., India). Nature, 211: 1167-8(Sept. 10, 1966).

During the past few years evidence was obtained for the existence of thermal nonequilibrium in the F region of the ionosphere. Several electron temperature measurements in the ionosphere are discussed. The influence of solar radiation on the electron heating was investigated. (M.O.W.)

**698** CONFIGURATION AND POPULATION OF THE EARTH'S MAGNETOSPHERE IN THE SOLAR WIND. Pfotzer, G. (Max-Planck-Institut fuer Aeronomie, Lindau ueber Northeim, Ger.). 6p. of Deutsche Gesellschaft fuer Raketentechnik und Raumfahrt, Symposion ueber die Erforschung des Mondes und des Interplanetaren Raumes, Munich, West Germany, Apr. 22, 1966. (In German).

A brief outline is given of the major developments in the study of fluctuations of the earth's magnetosphere, since the first observations by Graham in 1722. A chronology of major observations and diagrams of the structure and population of the magnetosphere are included. (IAA)

**699** ELECTRON IONIZATION AND LOSS PROCESSES AND RATES. Crain, C. M. (RAND Corp., Santa Monica, Calif.). 51p. (CONF-660439-4). ORAU. Gmelin, AED-CONF-66-063-5.

From Conference on Ground-Based Aeronomic Studies of the Lower Ionosphere, Ottawa.

Factors relating to the ionization state in the lower ionosphere below roughly 100 km are summarized. Ionization sources considered include x rays, Lyman $\alpha$ radiation, cosmic rays, protons, electrons, $\alpha$ particles, $\beta$ particles and $\gamma$ radiation from fission debris, and neutron-decay $\beta$ particles. Two general approaches to the study of ionization loss in the lower atmosphere are considered: the lumped-parameter approach and the multiple species–chemical kinetic approach. Areas of uncertainty in the approaches are emphasized, and examples illustrating the implications of some of these uncertainties are included. (A.G.W.)

**700** EARLY RESULTS FROM THE TOPSIDE SOUNDER IN THE ALOUETTE II SATELLITE. Nelms, G. L.; Lockwood, G. E. K. (Defence Research Telecommunications Establishment, Ottawa). 41p. (CONF-660401-13). ORAU. Gmelin, AED-CONF-66-061-30.

From American Meteorological Society, American Geophysical Union, Annual Joint Meeting, Washington, D. C.

The Alouette II satellite was launched on November 29, 1965, into an 80° inclination elliptical orbit, with apogee of 3000 km and perigee of 500 km. Some of the early results from the sweep frequency topside sounder experiment of the satellite are described. Examples are given of ionograms obtained when the satellite was near perigee and near apogee at mid- and at high latitudes. The accuracy with which the frequency of various plasma phenomena can be determined from the sample ionograms is discussed. A new type of plasma resonance spike was identified; its characteristics and the plasma conditions under which it is observed are described. Electron number densities less than 500 electrons/cm$^3$ are found at the higher portions of the orbit over much of the polar region. The boundaries of the low density region are shown for early December 1965 and late January 1966. The southern boundary of this low density region is shown to be near the location of the sharp trough that occurs at the peak of the F layer. Height profiles of electron density are calculated from the ionograms. Contours of constant electron density as a function of altitude and latitude along the path of the satellite are presented for four near-apogee passes, two over the equator and two over the north polar region. At 1500 to 2000 km the mid-latitude scale heights were four times as large as over the polar region. The polar scale heights were twice as large at 2500 km as at 1500 km. (auth)

**701** F-REGION TEMPERATURES AND ELECTRON DENSITIES USING INCOHERENT BACKSCATTER. Rao, P. B. (Arecibo Ionospheric Observatory, Puerto Rico). 27p. (CONF-660443-4). ORAU. Gmelin, AED-CONF-66-142-14.

From International Scientific Radio Union Conference, Washington, D. C.

Electron densities and electron and ion temperatures in the ionosphere were measured by means of ground based radar observations at the Arecibo Ionospheric Observatory (18.4°N, 66.9°W). The experimental technique makes use of a spherical dish antenna of 1000 ft in diameter and a pulse transmitter capable of delivering a peak power of 2.5 MW at the operating frequency of 430 Mc/sec. Observations made at approximately weekly intervals for periods lasting 24 to 30 hours during the summer 1965 were studied in detail for diurnal variations in the electron density profiles and electron and ion temperatures. Plasma scale heights were calculated for the region extending from 450 to 700 km assuming the electron density distribution under diffusive equilibrium. These values have shown increasing proportion of light ions in the region above 500 km. Diurnal variation in the electron content measured up to a height of about 900 km reveals significant changes from day to day. Vertical transport velocity and ionization flux at various height levels were determined for the nighttime by making some assumptions in the integrated continuity equation. The diurnal variation of the electron temperature reveals a maximum that occurs usually between 0800 and 1100 hrs L. T. at all heights in the F region. The ion temperatures attain the maximum at about the same time as the electron temperature, but they maintain around that value for longer periods. The rate of increase in the electron temperature after local sunrise is found to be considerably greater than the rate of decrease on sunset. The difference between these rates is much less in the case of ion temperatures. The electron to ion temperature ratio attains a maximum value ~2.5–3.0 at a height of about 300 km and at a time ~0800 to 1000 hrs L. T. At night the ratio is mostly found to be between 1.0 and 1.5. Perfect equilibrium condition, if ever exists, will usually be for 2 to 3 hours around midnight. (auth)

**702** ACCELERATION OF GEOMAGNETICALLY-TRAPPED ELECTRONS BY VARIATIONS OF IONOSPHERIC CURRENTS. Cladis, John B. (Lockheed Palo Alto Research Labs., Palo Alto, Calif.). 23p. (CONF-660401-12). ORAU. Gmelin, AED-CONF-66-061-26.

From American Meteorological Society, American Geophysical Union, Annual Joint Meeting, Washington, D. C.

Evidence for the acceleration of trapped particles by magnetic fluctuations produced by ionospheric currents is derived from the observations of sharp-energy groups of high-energy electrons which, at least on one occasion, appeared suddenly at low L shells (L ~ 1.15). An analysis of magnetograms recorded during the onset times of the electrons suggests the action of a quasi-resonance process whereby the electrons were accelerated by fluctuations in the intensity of the equatorial electrojet which had periods comparable to the azimuthal drift periods of the electrons. The energy imparted to the electrons by this process was small but sufficient to cause the electrons, through failure of the third adiabatic invariant, to move to the low L shells from somewhat higher L shells where appropriate fluxes of the electrons were already present. Energy spectra computed on the basis of this acceleration mechanism are in agreement with the measurements. It is also suggested that the variations of the equatorial electrojet intensity were caused by the precipitation of trapped particles in the vicinity of the Brazilian geomagnetic minimum. (auth)

**703** LABORATORY SIMULATION OF GEOPHYSICAL PHENOMENA. Osborne, F. J. F.; Bachynski, M. P.; Gore, J. V.; Kasha, M. A. (RCA Victor Co., Ltd., Montreal). 4p. (CONF-651146-2). ORAU. Gmelin, AED-CONF-66-349-10.

From 2nd American Astronautical Symposium, Coral Gables, Fla.

Two different experiments are described in which complex geophysical phenomena were simulated in the laboratory. The first experiment is a scaled laboratory study of the interaction between the solar wind and the magnetosphere. The second experiment deals with the perturbation induced by a space satellite with long antennas in the surrounding environment due to the motion of the satellite in a magnetized plasma. The geophysical situation relevant to each experiment is described, as well as the laboratory arrangement and the interpretation and significance of the experimental results. (auth)

**704** PRECIPITATION OF 400 Kev ELECTRONS IN THE AURORAL ZONE. Blake, J. B.; Freden, S. C.; Paulikas, G. A. (Aerospace Corp., El Segundo, Calif.). 19p. (CONF-660401-14). ORAU. Gmelin, AED-CONF-66-061-31.

From American Meteorological Society, American Geophysical Union, Annual Joint Meeting, Washington, D. C.

Measurements of precipitating electrons with E > 400 keV were made with a solid-state detector from February 25 to March 10, 1965, aboard a near polar satellite at

altitudes from 170 to 220 km. Auroral zone data were taken ($3.5 \leq L \leq 7.5$) in two longitude intervals (170°E to 225°E and 278°E to 300°E). During every auroral zone pass a flux of electrons, E > 400 keV, was observed ranging from $10^3$ electrons/cm$^2$-second to $10^5$ electrons/cm$^2$-second while at other latitudes the maximum flux observed was less than 150 electrons/cm$^2$-second. For the 278° to 300° longitude interval the conjugate points were mostly below 100 km. Fine temporal or spatial variations were observed during one pass; the flux changed by up to a factor of five in a few tenths of a second. (auth)

## Low-Temperature Physics

**705** (AD-634481) DETERMINATION OF KAPPA-1 (T) AND KAPPA-2 (T) FOR TYPE TWO SUPERCONDUCTORS WITH ARBITRARY IMPURITY CONCENTRATION. Eilenberger, Gert (Cornell Univ., Ithaca, N. Y. Lab. of Atomic and Solid State Physics). May 1966. Contract Nonr-401(38). 72p. CFSTI $3.00 cy, $0.75 mn.

Formulas are derived for the constants kappa-1 and kappa-2 of superconducting alloys for arbitrary temperatures and impurity concentrations. Beginning with Gorkov's equations in matrix-form, the free energy density is calculated using Abrikosov's assumption of a fluxoid lattice. The impurities are treated by the usual averaging technique, retaining only s- and p-scattering, and a special technique is developed to treat exactly the nonvanishing commutator of different components of the gage invariant derivative. The results contain the already known limiting cases. Intermediate values are obtained by performing machine calculations using the general formulas developed here. It is found that the values of kappa-1 and kappa-2 drop relatively strongly even for small impurity concentration, and also depend unexpectedly strongly on the ratio of sand p-scattering. The recent result of Cyrot, Caroli and de Gennes is confirmed according to which kappa-2 is approximately equal to kappa-1 in the firty limit. (auth)

**706** (ANL-Trans-356) HORIZONTAL CRYOSTAT FOR TARGETS OF POLARIZED PROTONS. Roubeau, P. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Translated for Argonne National Lab., Ill., from report SPSRM-65/30. 95p. Dep. mn. JCL $8.60 fs, $3.05 mf.

The construction of a cryostat for polarized-particle targets is discussed. The cryostat system has continuous circulation with the following qualities: precise and stable positioning; stable temperature; autonomy of the order of 24 hours, changing of the vessel in 10 minutes; space occupied reduced to a cone of 30° practically parallel to the bundle if it is desired; and an exchanger saving up to 50% of the helium. The cryogenic equipment includes: (1) dewar vessels for storing liquid helium; (2) a canal system for transfer of liquid helium; (3) the cryostat which includes a hyperfrequency cavity, chambers, and inside elements; (4) the temperature and pressure indicators; and (5) the pumping pipelines and vacuum pumps. (J.H.M.)

**707** STRUCTURE IN THE PRECURSOR ABSORPTION IN SUPERCONDUCTING LEAD. Norman, Scott L.; Douglass, David H. Jr. (Univ. of Chicago). Phys. Rev. Lett., 17: 875-7(Oct. 17, 1966).

The precursor absorption is found to consist of two peaks at 14.3 and 17 cm$^{-1}$, respectively. Additional structure, possibly associated with critical gaps seen in tunneling experiments, is discussed. (auth)

**708** MEASUREMENT OF MAGNETIC FIELDS AT LIQUID HELIUM TEMPERATURES. Hill, D. A.; Hwang, C. (Northwestern Univ., Evanston, Ill.). J. Sci. Instrum., 43: 581-4(Aug. 1966).

Two types of magnetometer are described, both capable of measuring magnetic fields to better than 1 G in 25 kG at the temperature of liquid helium. The first is a marginal oscillator of range 7 to 150 Mc/s employing a single probe throughout this frequency range. $^{19}$F and $^{23}$Na field probes were satisfactorily used with this oscillator in liquid helium at 25 kG. The extrapolated field capacity of the $^{23}$Na probe used with this oscillator can be as high as 130 kG. The second magnetometer uses a Hall device driven at 400 c/s in conjunction with null-balance ac detection. Two types of Hall probe are discussed and typical calibration curves over the region 2 to 25 kG at 4.2°K are presented. (auth)

**709** PARALLEL CRITICAL FIELDS OF TYPE-I TIN FILMS. Tilley, D. R.; Baldwin, J. P.; Robinson, G. (Mullard Research Lab., Redhill, Eng.). Proc. Phys. Soc. (London), 89: 645-59(Nov. 1966).

The predictions of the Ginzburg-Landau theory as given by Ginzburg and Landau and by Saint-James and de Gennes are compared for the thermodynamic critical field and the supercooling field of a film in a parallel field with resistance and torque magnetometer measurements on tin films. Results suggest that, except in the immediate neighborhood of the critical temperature, the transitions are governed by a filamentary network. (auth)

**710** PARAMETRIC AMPLIFICATION AND OSCILLATIONS IN STRUCTURED SUPERCONDUCTING TIN FILMS. D'Aiello, R. V. (RCA Labs., Princeton, N. J.); Freedman, S. J. Appl. Phys. Lett., 9: 323-5(Nov. 1, 1966).

Parametric amplification and side-band oscillations were observed using thin superconducting films at 7.2 GHz. The amplification and oscillations are associated with discontinuities in the pump power vs frequency response of the films and with slits cut into the films. When operated in a parametric mode, a net gain of 12 dB was achieved. The oscillations occur in symmetrical pairs about the pump at 1-MHz intervals and are very sensitive to an applied d-c magnetic field of approximately 0.1 G. (auth)

**711** POSSIBILITY OF SUPERCONDUCTIVITY IN ORGANIC MACROMOLECULES. Little, W. A. (Stanford Univ., Calif.). 23p. (CONF-660641-1). ORAU. Gmelin, AED-CONF-66-220-1.

From 3rd Biennial Polymer Symposium, Cleveland.

A recent suggestion that superconductivity might be able to occur in certain types of organic macromolecules at temperatures near room temperature is discussed. A brief review of the present understanding of the microscopic theory of superconductivity is given first and from this it is argued why superconductivity should be able to occur in certain highly specific types of organic macromolecules. Why the transition temperature for the onset of superconductivity should be high compared to that of metallic superconductors is discussed. Progress in the understanding of certain limitations of the original arguments and recent developments in this field are reviewed, including a discussion of some highly specific macromolecule-macromolecule interactions which these hypothetical materials should exhibit. (auth)

**712** HEAT TRANSFER TO BOILING LIQUID HELIUM IN NARROW VERTICAL CHANNELS. Wilson, M. N. (Rutherford Lab., Chilton, Eng.). 5p. (CONF-660628-12). ORAU. Gmelin, AED-CONF-66-173-13.

From International Inst. of Refrigeration Commission I Meeting, Boulder, Colo.

Work was undertaken to provide information for the design of large stabilized superconducting magnets. Although many detailed measurements have been made on heated surfaces in an open bath of boiling liquid helium, no information has so far been available on how the heat transfer characteristics are changed when the liquid is confined in a narrow channel. Measurements are reported which have been made on vertical channels, of rectangular cross section, over a range of channel heights and widths. The nucleate pool boiling region was considered and, in particular, the point of transition from pool to film boiling. (W.D.M.)

**713** THERMAL BOUNDARY RESISTANCE AND RELATED PEAK FLUX DURING SUPERCRITICAL HEAT TRANSPORT FROM A HORIZONTAL SURFACE THROUGH A SHORT TUBE TO A SATURATED BATH OF LIQUID He II. Clement, B. W.; Frederking, T. H. K. (Univ. of California, Los Angeles). 18p. (CONF-660628-8). ORAU. Gmelin, AED-CONF-66-173-7.

From International Inst. of Refrigeration Commission I Meeting, Boulder, Colo.

Cryostats often incorporate reservoirs connected by means of channels with comparatively small cross sections which constitute a large impedance to normal fluid flow, or heat transfer, respectively. Since little is known about the peak flux in channels, experiments have been conducted with the purpose of determining the peak flux for zero mass flow in an insulated tube of large diameter. Heat was supplied at one end of a tube from the face of a silver cylinder. The entire apparatus was immersed in a He II reservoir. (W.D.M.)

**714** LARGE-SCALE HELIUM LIQUEFIER. Trepp, Ch. (Sulzer Bros. Ltd., Winterthur, Switzerland). 15p. (CONF-660628-9). ORAU. Gmelin, AED-CONF-66-173-8.

From International Inst. of Refrigeration Commission I Meeting, Boulder, Colo.

The first major plant which liquefies helium purely for transportation purposes was installed at Otis, Kansas, as part of a helium extraction facility. The liquefier was designed for a capacity of 800 liters of liquid helium per hour. On the grounds of reliability a process was chosen using work-performing expansion in cold gas turbines to generate the refrigeration necessary for liquefaction. It is described how plant components were grouped together, and what influence these individual components have on the overall plant efficiency. (W.D.M.)

**715** LIQUID HELIUM TECHNOLOGY AT THE NATIONAL BUREAU OF STANDARDS. Scott, R. B. (National Bureau of Standards, Boulder, Colo.). 15p. (CONF-660628-11). ORAU. Gmelin, AED-CONF-66-173-14.

From International Inst. of Refrigeration Commission I Meeting, Boulder, Colo.

A general review of the work carried out by the National Bureau of Standards on liquid helium technology since 1934 is presented. (W.D.M.)

**716** NOISE ASSOCIATED WITH HEAT TRANSFER TO LIQUID HELIUM II. Bussieres, P.; Leonard, A. C. (Royal Military Coll., Kingston, Ont.). 28p. (CONF-660628-10). ORAU. Gmelin, AED-CONF-66-173-15.

From International Inst. of Refrigeration Commission I Meeting, Boulder, Colo.

Heat transfer from a solid to a pool of liquid helium II at high temperature difference can be accompanied by a characteristic sound under certain conditions. The phenomenon is such that these conditions can also be exactly duplicated without the occurrence of noise. The gaseous formations which accompany each mechanism are different from each other. The mechanism without noise has been previously examined and no reference to heat transfer to helium II acompanied by noise could be found in the literature. A qualitative analysis is presented of the factors required for the occurrence of the noise. They appear to be closely associated with the jump from convection to film boiling heat transfer. The heat flux, depth of immersion and saturation pressure required to stop the mechanism were quantitatively determined up to a depth of 20 cm and a heat flux of 40 watts/cm$^2$. High speed photographs of the gaseous formations accompanying each mechanism were obtained. Large, irregularly shaped bubbles or cavities which grow and collapse very rapidly characterized the heat transfer with noise. This mechanism is not as efficient a heat transfer mechanism as the film boiling heat transfer without noise. The sound produced was analyzed at several heat fluxes. It is essentially white noise with a predominance of high frequencies and is very similar in nature to the noise produced by the nucleate boiling of conventional liquids. The overall sound level varies directly as the heat flux but the frequency distribution is not significantly affected by heat flux. The existence of two distinct heat transfer mechanisms at high temperature difference was demonstrated. (auth)

**717** SUPERCONDUCTIVITY AND ELECTRONIC STRUCTURE IN THE ALLOY SYSTEM LEAD–THALLIUM. Claeson, T. (Univ. of California, San Diego, La Jolla). 32p. (CONF-660327-10). ORAU. Gmelin, AED-CONF-66-050-33.

From American Physical Society Meeting, Durham, N. C.

The superconducting transition temperatures of Pb–Tl alloys covering the entire composition range were determined. The $T_c$'s of the alloys are in general intermediate between those of Pb and Tl, except for samples in the concentration range 75 to 85 at. % Tl, for which the $T_c$'s are lower. Two other features, a continuous change of slope of $T_c$ versus composition, and a small peak structure in $T_c$, occur at about the 50 at. % composition. These features, which occur in the fcc (Pb) phase might arise from a Brillouin zone effect of the Merriam type. If the model for the Fermi surface in lead proposed by Anderson and Gold (based upon their de Haas–van Alphen data and using the orthogonalized plane wave method) is employed, such an effect would be expected at the composition observed. On the other hand, an order–disorder transformation might contribute to the observed effects. A speculation regarding a connection between the electronic structure effect and a possible ordering process is made. Superconductivity behavior suggests an extension of the Pb solid solution, in a limited temperature interval, to higher Tl concentrations than those in the accepted phase diagram. The terminal solid solubility of Tl in Pb is found to be 88 ± 2 at. % at 25°C and at 295°C. The solubility of Pb in $\alpha$ Tl is 2.5 ± 1 at. % at 25°C; in $\beta$ Tl it is 5 ± 1 at. % at 295°C. The T 's of a few Bi–Tl samples were also measured. Structure, similar to that at $Pb_{.50}Tl_{.50}$, appeared in the $T_c$ curve at $Bi_{.15}Tl_{.85}$. (auth)

**718** TIME VARIATION OF THE GINZBURG-LANDAU ORDER PARAMETER. Abrahams, Elihu; Tsuneto, Toshihiko (Rutgers Univ., New Brunswick, N. J.). 55p. (CONF-660327-12). ORAU. Gmelin, AED-CONF-66-050-34.

From American Physical Society Meeting, Durham, N. C.

A nonequilibrium form of the Green's function formulation of the BCS theory of superconductivity is used to investigate the circumstances under which differential equations in space and time, i.e., "time dependent Ginzburg–Landau equations," give a valid description of the space and time variation of the order parameter $\psi$ in superconductors. It is found that if the variations are sufficiently slow, time dependent Ginzburg–Landau equations exist near absolute zero and near the transition temperature. In the former case, the equation has wave-like character and in the latter case it is of diffusion type with the restriction that either the characteristic frequency of the time variation of $\psi$ is greater than the gap frequency or the ratio of the Fermi velocity to the product of the characteristic wave length and frequency of the space–time variation of $\psi$ is greater than unity. Under all other circumstances and at general temperatures, there are no differential equations to describe the variations of $\psi$. The influence of slowly varying time dependent fields is also discussed and the dependence of charge and current densities on the variations of $\psi$ is derived. Local electrodynamics are assumed. The necessary modifications for the case of dilute superconducting alloys are described. Applications are made to the questions of collective modes, nucleation and London's theory near absolute zero. (auth)

**719** POOL BOILING HEAT TRANSFER IN LIQUID NEON. Astruc, J. M. (CEN, Grenoble, France); Lacaze, A.; Perroud, P.; Weil, L. 19p. (CONF-660605-10). ORAU. Gmelin, AED-CONF-66-170-13.

From Cryogenic Engineering Conference, Boulder, Colo.

Experimental results for pool boiling heat transfer in liquid neon are presented. The heating elements consisted of wires 49 cm long, and placed horizontally in a pool of boiling liquid neon. For free convection and nucleate boiling regimes, measurements were made at pressures varying from atmospheric to 23 bars ($P_c$ = 26.5 bars), with a platinum wire (diameter 0.015 cm) directly heated by the Joule effect (d-c). For the film boiling regime, experimental results were obtained at atmospheric pressure only, with wires made of platinum (dia 0.02 cm) and lead (dia 0.05 and 0.2 cm), the energy transferred to the liquid being then supplied by heat stored in the wires. The maximum nucleate boiling heat flux (burnout) at atmospheric pressure was 6 w/cm$^2$ at $\Delta T_{sat}$ = 2.8°C; when the pressure was increased this heat flux reached a maximum of about 14 w/cm$^2$ at a reduced pressure $P/P_c \simeq 0.35$, then decreased. Hysteresis appeared at low heat fluxes in nucleate boiling at intermediate pressures. Comparison of experimental data with those given in the literature and with certain existing theories was made. (auth)

# Plasma and Thermonuclear Physics

*Refer also to abstract 98.*

## Confinement and Heating of Plasma

*Refer also to abstract 803.*

**720** (AD-632344) HIGH-POWER MAGNETICALLY CONFINED PLASMA DUPLEXER. Report No. 9 (Final), May 31, 1963–August 31, 1965. Langberg, Edwin; Ghen, William R. (Elcon Lab., Inc., Peabody, Mass.). Contract DA-36-039-AMC-02364(E). 238p. (ECOM-02364-F). CFSTI $6.00 cy, $1.25 mn.

The theory of confining a microwave gas plasma discharge by means of a magnetic field is presented. Two types of magnetic fields, cusp shaped and mirror, are analyzed. Both type fields are investigated experimentally using suitable microwave cavity structures and plasma containers. The high power experimental microwave equipment uses a traveling wave resonant ring simulator to ionize the plasma at pulsed powers up to 70 MW peak, 70 kW average. The major technical problem associated with the use of a stable confinement system is the inherently long recovery time. The use of both chlorine as an attaching gas and a quartz wool filled plasma container reduces recovery time to practical ranges, but conflicts somewhat with the fundamental principles of confinement. The use of a quartz wool filled plasma container with cusp magnetic field seems to provide the best compromise between magnetic confinement principles and microwave performance. (auth)

**721** (AD-632379) TOROIDAL PLASMA CONTAINMENT WITH ROTATING MAGNETIC FIELD. Final Report. Brown, D. E.; Loos, H. G. (Giannini Scientific Corp., Santa Ana, Calif.). Apr. 1966. Contract AF49(638)-1539. 49p. (AFOSR-66-0778). CFSTI $2.00 cy, $0.50 mn.

Experimental investigations were conducted on a toroidal plasma with alternating pinch- and $\theta$-pinch magnetic fields as well as with a $\theta$ pinch and with a screw pinch. For the alternating pinch, the resultant magnetic vector is rotating, so that there are no periodic zeros in the containing magnetic pressure, and containment times for high plasmas may possibly be extended beyond one-half cycle. Also, for field rotation frequencies much smaller than the electron collision frequency, shear occurs in the magnetic field through the skin of the plasma, thereby improving the plasma stability. If the current sheet thickness measured from the oscillograms is taken as skin depth, Suydam's necessary condition for stability of a linear pinch with a rotating magnetic field is not satisfied in our experiments. The "fanning" effect occurring right after the plasma compression in the second half cycle in toroidal $\theta$ pinches is quenched by the rotating field, but plasma conditions for the $\theta$ pinch and for the alternating pinch are not comparable on account of the inhibiting effect of the pinch magnetic field on the ionization caused by the $\theta$-pinch field. (auth)

**722** (AD-635779) TRI-DIMENSIONAL PLASMA COMPRESSION ASSEMBLIES. Josephson, V. (Aerospace Corp., El Segundo, Calif.). Dec. 1965. Contract AF04(695)-669. 17p. (SSD-TR-66-108). CFSTI $1.00 cy, $0.50 mn.

Two configurations for achieving tri-dimensional plasma compression were designed, and preliminary testing was accomplished on one. The results indicate that the configuration does produce very high plasma temperatures as a result of the compression; this is evidenced by the sharp (>1 microsec), intense (>$10^9$) burst of neutrons resulting from the compression and heating of a deuterium plasma to fusion temperatures. (auth)

**723** (AD-636120) ON THE EQUILIBRIUM OF ELECTRON CLOUDS IN TOROIDAL MAGNETIC FIELDS. Daugherty, J. D.; Levy, R. H. (Avco-Everett Research Lab., Everett, Mass.). May 1966. Contracts NAS8-20310; AF49(638)-1553. 32p. (Avco-RR-248). CFSTI $2.00 cy, $0.50 mn.

The self-consistent equilibrium configurations available to low density toroidal electron clouds under the influence of an external magnetic field and the electric fields due to space and image charges are discussed. The equilibria are dynamic rather than static, but steady. Delta-B, centrifugal, and other drifts are shown to be unimportant, in contrast to the situation in toroidal neutral plasmas. Typical equilibria are shown in detail, to zero order in q. The construction of equilibria accurate to order q is shown to be possible but is not carried out in detail. (auth)

**724** MAGNETIC FIELD GEOMETRY AND THE ADIABATIC INVARIANTS OF PARTICLE MOTION. Siambis, John G. (Massachusetts Inst. of Tech., Cambridge); Northrop, Theodore G. Phys. Fluids, 9: 2001-5(Oct. 1966).

The first correction term to the lowest-order magnetic moment of a charged particle is written in terms of the curl of the magnetic field and the eight coefficients specifying the torsions, shears, and curvatures of the field lines. Certain of the coefficients are absent; thus in a vacuum field the lowest-order magnetic moment will not be affected by them. The influence of field geometry on the first correction to the second invariant is also investigated. A surface on which the lowest-order term of the invariant is constant is composed of field lines, as is well known. In portions of a surface, where the field lines have large components of curvature tangent to the surface, the first-order correction term is large, and the guiding center deviates from the surface more than where the radii of field line curvature are normal to the surface. This fact explains some phenomena observed in recent numerical integrations of guiding-center trajectories in Ioffe-type mirror geometries. (auth)

**725** MAGNETIC MOMENT TO SECOND ORDER FOR AXISYMMETRIC STATIC FIELD. Gardner, C. S. (Princeton Univ., N. J.). Phys. Fluids, 9: 1997-2000 (Oct. 1966).

The magnetic moment of a charged particle of small mass moving in a magnetic field is a series (in general not convergent), $\mu = \mu_0 + \epsilon\mu_1 + \epsilon^2\mu_2 + \ldots$, where $\mu_0 = v_\perp^2/B$, $\epsilon = m/e$ and where $\mu_1$, $\mu_2$ are functions of the spacial coordinates and velocity components of the particle. The series $\mu$ has the property that its time derivative is formally zero. A formula is given for the first-order correction $\mu_1$ by Kruskal for a general field. The formula is given for the second-order correction $\mu_2$, for the special case of a static magnetic field with axial symmetry. (auth)

**726** VLASOV EQUATION STUDY OF PLASMA MOTION ACROSS MAGNETIC FIELDS. Sestero, A. (EURATOM-CNEN, Frascati, Italy). Phys. Fluids, 9: 2006-13(Oct. 1966).

A description is given, in terms of distribution functions, of the phenomenon of a plasma crossing magnetic field lines by virtue of beam polarization. The task requires solving two steady-state, nonlinear Vlasov equations for ions and electrons, coupled with Maxwell's equations. Studying the plasma in a neighborhood of the moving beam surface, a distinction is made between two asymptotic regions of plasma in equilibrium, and an intermediate, transition region. In the so-called charge-neutral approximation, actual transition profiles are computed in closed form, in terms of quadratures. Some general conclusions are drawn concerning the minimum width of the transition region and the maximum change in the macroscopic velocity that the plasma can support over such minimum distance. (auth)

**727** PLASMA HEATING AND DIFFUSION IN STOCHASTIC FIELDS. Puri, S. (Stanford Univ., Calif.). Phys. Fluids, 9: 2043-6(Oct. 1966).

Motion of electrons in a static magnetic field and a transverse random electric field is analyzed. A plasma consisting of "test particles" is found to extract energy from the electric field. Heating proceeds linearly in time, and the plasma retains a Maxwellian velocity distribution. The heating and diffusion rates were computed in terms of the power spectrum of the fluctuating electric fields of arbitrary strength. (auth)

**728** CURVED-FIELD PLASMA TRANSMISSION INTO A MIRROR MACHINE. Oleson, Norman L.; Steinhaus, James F.; Barr, William L. (Univ. of California, Livermore). Phys. Fluids, 9: 2056-8(Oct. 1966). (UCRL-14474).

Plasma from an occluded-gas hydrogenated titanium-washer source was transmitted into a mirror machine along the field lines of a magnetic cusp formed at one end of the system. The results are compared with those produced by an identical gun located at a mirror on the magnet coil axis. Measurements indicate that in low magnetic fields, heavy ions strike the walls, producing neutrals that are subsequently excited and ionized by the contained plasma. At high magnetic fields (~6 kG at the mirrors), all ions appear to turn the corner but a radial profile of the ion density is asymmetric. A peak density of $1 \times 10^{13}$ H ions/cm$^3$ is indicated near the mirror axis, agreeing with the results found by other investigators with toroidal or double-bend magnetic field geometries. (auth)

**729** CONFINEMENT OF PLASMA HEATED BY ION CYCLOTRON RESONANCE IN THE C STELLARATOR. Pease, R. S.; Yoshikawa, S.; Eubank, H. P. (Princeton Univ., N. J.). Phys. Fluids, 9: 2059-70(Oct. 1966). (MATT-387).

Microwave interferometric measurements of electron density, measurements of the particle flux to the divertor and of electron and ion cooling rates, were used to obtain confinement times $\tau_c$ of deuterium plasma ($T_e$ up to 80 eV, $T_i$ up to 200 eV, and mean density 0.5 to $5 \times 10^{12}$ cm$^{-3}$) in the C stellarator. These times are consistent with a Bohm-type pumpout law, $\tau_c = 10^{-8}\, 2\pi r_0^2\, B/T_e$ sec, where B is in G, $r_0$ (plasma radius) in cm, and $T_e$ in eV, and are found to be insensitive to shear, to $T_i$, and to longitudinal current density with associated drift velocity in the range 0.2 to 7 times the plasma acoustic velocity. The enhancement of plasma temperature produced by ion cyclotron heating is accompanied by enhanced fluctuations in the frequency range of 10 kc/sec to 1 Mc/sec. The particle loss calculated from the fluctuations seems consistent with the measured value of $\tau_c$, although the measured $\tau_c$ may be determined by other effects, such as the scrape-off layer effect. No improvement in respect of confinement or of fluctuations was detected in a minimum-average-B geometry of 1% well depth. The plasma confinement may have been limited by the lack of detailed toroidal equilibrium. Theoretically, the plasma is unstable both to the universal and to the resistive and kinetic ballooning modes within the plasma duration. (auth)

**730** ELECTROLYTIC TANK ANALOG FOR MAGNETIC FIELD DESIGN. Combes, Lewis S.; Gallagher, Charles C.; Levine, Morton A. (Air Force Cambridge Research Labs., Bedford, Mass.). Rev. Sci. Instrum., 37: 1567-70(Nov. 1966).

An electrolytic tank serves as a relatively easy and reasonably accurate method of analoging magnetic field configurations. A simplified tank was constructed for designing a field to be used in a plasma containment device. The tank is useful in determining the parameters for the field producing coils and for mapping isogaussic surfaces that may result when a high density plasma is present in the magnetic field. In this analog tank, the current density in the electrolyte is directly proportional to the magnetic flux density and, from this relationship, equations were derived by which flux density, magnetomotive force, total flux, inductance, and energy of the coils can be found from tank measurements. The detailed analysis of a specific magnetic field problem is given. (auth)

**731** EVALUATION OF FARADAY SHIELDED STIX COILS FOR ION CYCLOTRON RESONANCE HEATING OF PLASMA. Dodge, N. B.; Kristiansen, M.; Dougal, A. A. (Univ. of Texas, Austin). Rev. Sci. Instrum., 37: 1455-9(Nov. 1966).

The spatial waveform of the azimuthal electric field $E_\theta$ of the Stix coil is investigated. Methods are developed to improve the $E_\theta$ waveform by making it more nearly sinusoidal. Varying the spacing between individual coil turns in the coil section, along with the use of a "squirrel cage" type Faraday shield, is found to give a more nearly sinusoidal waveform. The effect of a number of Faraday shields on the $E_\theta$ waveform is also presented, and it is found that certain types of shields, notably the single slit copper cylinder shield, introduce distortions into the accelerating ($E_\theta$) field. The efficiency of these shields in reducing the longitudinal electric field $E_z$ is reported. Several are found to be efficient $E_z$ shields, except for a Faraday shield placed outside the Stix coil. The effect of Faraday shields on the equivalent circuit parameters of the Stix coil is also determined, and the variation of these parameters among the various shields is tabulated. (auth)

**732** DIFFUSION OF TOROIDAL DISCHARGE PLASMA. Kadomtsev, B. B.; Shafranov, V. D. Dokl. Akad. Nauk SSSR, 167: 1273-5(Apr. 21, 1966). (In Russian).

A formula was derived for plasma diffusion current in a toroidal axially symmetric discharge in the presence of a vortex electric field. In this case, the rate of plasma expansion can be assumed, in principle, to be equal to zero. In a constant longitudinal field ($E_{\omega_0} = 0$) the compensation for diffusion is possible only with comparatively low plasma pressure, $p \sim \beta_{\omega_0}^2 / 8\pi q^2$. (R.V.J.)

**733** MOVING STRIATIONS IN A LONGITUDINALLY MAGNETIZED PLASMA COLUMN. Yatsui, Kiyoshi; Inuishi, Yoshio. Technol. Rep. Osaka Univ., 16: 141-51 (Mar. 1966).

Relation between moving striations and anomalous diffusion effect is experimentally studied in a longitudinally magnetized positive column. The frequency, wavelength and velocity of striations decrease in the presence of magnetic field up to a certain strength, where a fairly good agreement with theory is obtained in dispersion curves. Above this region, another mode of striations with lower frequencies, lower velocities, and higher wavelengths builds up in the plasma to show irregularities in the dispersion relation, suggesting the existence of multiple modes of striations in the magnetized positive column. To determine the diffusion rate of charged particles across a magnetic field a new method of measuring ion current into probe is introduced, and the rapid damping of striations in the region of anomalous diffusion is made clear. (auth)

**734** THEORY OF GAS HEATING IN AXIALLY SYMMETRICAL WALL-STABILIZED ELECTRIC ARCS. Patt, H. J.; Schmitz, G. (Technische Hochschule, Aachen). Z. Phys., 195: 419-34(1966). (In German).

The analysis of gas heating phenomena in wall-stabilized electric arcs with axial gas flow derived in an earlier paper is applied to a nitrogen arc at a pressure of one atmosphere. For this reason the behavior of the inlet length, the perturbation quantities and the integral characteristic values of such an arc are discussed and their parameter dependences are investigated. The results give the best parameter values for getting the highest enthalpy flux and the best efficiency of the arc heater. (auth)

## *Diagnostics of Plasma*

**735** (AD-628890) PLASMA DENSITY BY ION BEAM PROBING; DENSITY AND SPECTROSCOPIC MEASUREMENTS OF ENERGETIC DEUTERIUM ARCS. Scientific Report No. 1, December 1, 1964-November 30, 1965. Hickok, Robert L.; Jobes, Forrest C.; Marshalland, John F.; Duncan, Samuel L. (Socony Mobil Oil Co., Inc., Princeton, N. J. Central Research Div. Lab.). Jan. 1966. Contract AF 49(638)-1500. 92p. (AFOSR-66-0285). CFSTI $9.60 cy, $0.75 mn.

The radial density distribution in a magnetically confined, energetic deuterium arc was measured by probing the arc with a 1.8-MeV deuteron beam. Integrated densities along a beam path were determined by measuring the proton production rate from the D(d,p)T reaction between the deuterons in the beam and in the arc. A zone calculation was used to invert the proton production data to a radial density distribution. Peak densities on the arc axis are in the range of 10 to the 13th power to 10 to the 14th power and the radius of the half density point is in the range of 1 to 2 cm. Spectroscopic observations of the arc were also made. Comparison with estimated spectral intensities, based on the density distribution and electron temperature, indicated that for high arc currents the neutral density is determined by the recombination rate but for low arc currents there appears to be an excess of neutral atoms. Macroscopic arc parameters, such as current and voltage, were used, together with the density distribution, in an idealized model of the arc to obtain values for the average electron temperature and plasma space potential. (auth)

**736** (AD-631517) USE OF A LANGMUIR PROBE FOR ELECTRON TEMPERATURE DETERMINATION IN A LASER-INDUCED PLASMA. Braerman, William F. (Ballistic Research Labs., Aberdeen Proving Ground, Md.). Dec. 1965. 49p. (BRL-MR-1715). CFSTI $2.00 cy, $0.50 mn.

The possibility of using Langmuir probes for electron temperature determination in a laser-induced plasma was investigated. Laser input energies less than 15 joules were used and electron temperatures on the order of 0.5 eV were inferred at various distances from the target. The beam was focused to approximately a 1 mm diameter spot. It is shown that the probe current at the start of the pulse follows the laser spiking. (auth)

**737** (AD-634808) INVESTIGATION OF PLASMA BY THE METHOD OF PROBING WITH BEAMS OF FAST PARTICLES. Krupnik, L. I.; Shulika, N. G. (Foreign Technology Div., Wright-Patterson AFB, Ohio). Feb. 16, 1966. 21p. (FTD-MT-65-101; TT-66-61582). CFSTI $1.00 cy, $0.50 mn.

Dense hydrogen plasmoids were investigated by probing them with beams of accelerated neutral and charged hydrogen particles. Investigations were made on the density of the plasmoid, its neutral component, its behavior in a magnetic field, and the radial distribution of plasma density in the plasmoid. (auth)

**738** (AD-640625) SPECTRAL CHARACTERISTICS OF A LOW DENSITY ARC-HEATED NITROGEN PLASMA. Price, L. L.; McGregor, W. K. (Aro, Inc., Arnold Air Force Station, Tenn.). Oct. 1966. 29p. (AEDC-TR-66-139). CFSTI $2.00 cy, $0.50 mn.

The visible and near ultraviolet spectrum from free jets of nitrogen plasmas produced by an arc-jet and exhausted into a low pressure (~1 torr) test cell was photographed under varying conditions. The spectral characteristics were compared to the spectra obtained from argon plasmas produced in the same apparatus. The characteristics of the argon spectra were attributed to the existence of long-lived metastable argon atoms; the nitrogen spectral characteristics were found to be interpretable in a similar way. The spectrum consisted of $N_2^+$ (first negative) and $N_2$ (second positive) band systems, N atomic lines, and strong impurity radiation from OH, NH, and NO. The impurity bands can be explained on the basis of the ambient test cell gases which mix in the jet boundary and become excited by collision of the second kind with nitrogen atomic and molecular metastables. Several gases, chiefly argon, were mixed with the nitrogen in order to investigate the possible collisions of the second kind and thus determine the mechanisms responsible for the radiation. Several possible mechanisms are proposed but complete explanation must await further study. The utility of the spectrum for diagnostic purposes was also investigated, and it was found that portions of the principal molecular bands are masked by the impurity radiation and that high resolution is required for their use in order to measure rotational temperature. (auth)

**739** (NASA-TN-D-3457) STEADY-STATE COMPOSITION OF A LOW-DENSITY NONEQUILIBRIUM HYDROGEN PLASMA. Krawec, Roman (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Oct. 1966. 19p. CFSTI $1.00 cy, $0.50 mn.

The steady-state composition of a hydrogen plasma is computed for both Maxwellian and non-Maxwellian electron energy distributions for the case in which only volume effects need be considered. The electron energy distribution function is so defined that it can be smoothly varied from Maxwellian to Druyvesteyn. Steady-state plasma equations are derived and are solved numerically for selected forms of this energy distribution. The results apply for plasmas that have a density of less than $10^{13}$ particles/cm$^3$. The gas is shown to be fully ionized for all distribution functions considered when the kinetic temperature of the electrons is above 4 ev. Certain regions of electron temperature are shown to exist in which Maxwellian and non-Maxwellian distributions predict substantially different plasma compositions. (auth)

**740** MEASUREMENTS OF MICROWAVES SCATTERED FROM A MOVING DENSITY-MODULATED PLASMA. Rice, D. K.; Wada, J. Y. (Univ. of Southern California, Los Angeles). Electron. Lett., 2: 385-7(Oct. 1966).

Measurements of the absolute intensity and the angular distribution of the microwaves scattered from an oscillating plasma column of a finite length are presented. These measurements show that the scattered wave produces diffraction patterns and frequency shifts. The results substantiate quantitatively the theory of nonlinear microwave scattering. (auth)

**741** NONLINEAR SCATTERING OF MICROWAVES BY A TRAVELLING-WAVE DENSITY-MODULATED PLASMA COLUMN. Wada, J. Y.; Rice, D. K. (Univ. of Southern California, Los Angeles). Electron. Lett., 2: 384-5(Oct. 1966).

A theory is presented which is based on the Born approximation of the nonlinear scattering of microwaves from a periodically density-modulated plasma column of finite length. It was shown quantitatively that the scattered waves produce diffraction patterns and frequency shifts; these scattered waves form a set of sidebands which are separated from the incident wave by the modulation frequency of an oscillating plasma column. (auth)

**742** DERIVATION FROM EXPERIMENT OF A FORMULA FOR THE NATURAL FREQUENCY OF A

QUASI-BOUND ELECTRON GAS. Dutt, T. L. (Northern Polytechnic, London). Proc. Phys. Soc. (London), 89: 717-22(Nov. 1966).

A formula for the natural resonant frequency $\omega_0$ of a quasi-bound electron gas is derived from an analysis of experimental results. $\omega_0$ is found to be a function of the product of the cube root of the electron density and the positive ion thermal velocity. The form of the expression for $\omega_0$ suggests that the quasi-bound gas be regarded as a gas of incoherent linear oscillators having very small energy of oscillation. (auth)

**743** DETERMINATION OF THE CONCENTRATION OF ELECTRONS IN AN A-C CARBON ARC. Lebedeva, V. V.; Romanov, N. P. Vestn. Moskov. Univ., Ser. III: Fiz. Astron., No. 6, 55-61(Nov.-Dec. 1965). (In Russian).

The electron concentration $N_e$ in a plasma in the range of $N_e = 2 \times 10^{15}$ to $10^{17}$ cm$^{-3}$ may be determined from the widening of the spectral lines by the Stark effect. Such measurements were carried out in an ac carbon arc burning in the air, on the basis of the width of the $H_\beta$ line. The hydrogen was introduced into the arc by wetting one of the electrodes with water or by impregnating it with the solution of a compound containing water of crystallization. The conditions required for observing the hydrogen, oxygen, and nitrogen lines during the initial moments after striking the arc were established. The electron concentration was measured at a time resolution of $5 \times 10^{-4}$ sec in the center of the arc, at currents ranging from 2.5 to 9 A and at distances between the electrodes from 1 to 4 mm; the discharge temperature was also measured simultaneously. At a current of 7 A and a distance of 3 mm between the electrodes, the electron concentration at the axis of the arc was found to be $N_e = 4.7 \times 10^{16}$ cm$^{-3}$, while the temperature was 10,600°K. (TTT)

**744** CALCULATED ION DISTRIBUTIONS IN A HELIUM NEGATIVE GLOW. Hurt, W. B. (Southwest Center for Advanced Studies, Dallas). J. Chem. Phys., 45: 3439-41(Nov. 1, 1966).

The spatial distributions of helium atomic and molecular ions in the negative glow are calculated assuming that both ions diffuse away from the cathode, that atomic ions are simultaneously being converted to molecular ions, and that both ions are being destroyed by recombination. Different assumptions are made relating the charge distributions to the intensity distributions with the result that a consistent diffusion–collisional–radiative recombination model best satisfies the experimental observations. (auth)

**745** SIMPLE METHOD FOR MEASURING ELECTRON DENSITY IN A PLASMA. Shtricker, J. (Hebrew Univ., Jerusalem). Appl. Phys. Lett., 9: 349-51(Nov. 1, 1966).

A simple method is presented for measuring electron densities in shock waves or plasmas. It measures the attenuation of low-power transmitted uhf waves through the plasma. The instrument has good time resolution and is inexpensive. It needs an independent absolute calibration. (auth)

**746** COMPARISON OF QUASISTATIC LINE PROFILES WITH MEASUREMENTS ON BALMER AND PASCHEN HYDROGEN LINES AND LINES OF THE DIFFUSE SERIES OF NEUTRAL HELIUM. Pfennig, H. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). J. Quant. Spectros. Radiative Transfer, 6: 549-56(Sept.-Oct. 1966).

The profiles of the Balmer lines of hydrogen and of the lines of the diffuse series of neutral helium being emitted from a plasma of relatively low electron density and temperature (H: $N_e = 1.3 \times 10^{13}$ cm$^{-3}$, T = 1850°K; He I: $N_e = 3.35 \times 10^{13}$ cm$^{-3}$, T = 1850°K) are compared with theoretical profiles based on a quasistatic treatment of the ions and electrons. For a region extending from the line wing to a point lying well inside of Holstein's frequency limit a satisfactory agreement with experiment can be achieved by using Ecker's microfield distribution folded with itself and by inserting values of the parameter $r_0/\lambda$ ($r_0 \approx$ mean particle distance, $\lambda$ = Debye length) being roughly twice as high as one would calculate from the values of $N_e$ and T. (auth)

**747** LANGMUIR PROBE ANALYSIS IN A POSITIVE COLUMN CONTAINING MOVING STRIATIONS. Woolsey, G. A.; Gray, E. W. (Queen's Univ., Belfast). J. Sci. Instrum., 43: 611-12(Aug. 1966).

An improved Langmuir probe technique is described, which allows detailed plasma parameter measurements to be made in a positive column containing moving striations. The technique is particularly applicable to electronegative discharges. (auth)

**748** SMALL SIZE PROBE FOR MEASURING ALTERNATING MAGNETIC FIELDS. Malkin, O. A.; Reis, I. A.; Stepanov, A. M. (All-Union Electrotechnical Inst., Moscow). Prib. Tekh. Eksp., No. 2, 151-3(Mar.-Apr. 1966). (In Russian).

Descriptions are given of a simple design for magnetic probes with an external diameter 1.2 to 1.6 mm and transducer coil turns 70 to 160, respectively. Oscillograms for the magnetic field changes with plasma propagation along the plate electrode are illustrated. (tr-auth)

**749** PLASMA PARTICLE SEPARATOR AND ANALYZER HAVING A GRID STRUCTURE CONSISTING OF LINEAR TUBULAR PORTIONS. Steinhaus, James F.; Passell, Thomas O. (to U. S. Atomic Energy Commission). U. S. Patent 3,288,993. Nov. 29, 1966.

A plasma particle separator, including a tubular grid structure, and means for generating a magnetic field of predetermined strength having a component perpendicular to the principal axis of the grid structure are described. The grid structure is disposed in receiving relation to plasma particles to be analyzed and a plasma particle detector is disposed to receive particles emergent therefrom. The magnetic field component causes particles of predetermined momentum-to-charge ratios to be deflected to impinge on the channel walls while those of other selected momentum-to-charge ratios pass through the tubular channels to impinge on the detector. (AEC)

**750** ION INJECTION EXPERIMENT AT FONTENAY. Prevot, F.; Bariaud, A.; Dei-Cas, R.; Fumelli, M.; Girard, J. P.; Gourdon, C.; Sledziewski, Z.; Valckx, F. P. G. (EURATOM-CEA, Fontenay-aux-Roses, France). 19p. (CONF-651126-28). ORAU. Gmelin, AED-CONF-65-353-73.

From American Physical Society, 7th Annual Meeting of the Division of Plasma Physics, San Francisco.

The experiment consists of injecting molecular hydrogen ions diametrically across a magnetic mirror configuration. The magnetic field is 11 kG in its center, and the mirror ratio is 3. After dissociation processes, a high-energy plasma is obtained. Different measurements on the hot plasma after beam cutoff and measurements made during the injection, emphasizing the measurements of hf radiation, are discussed. (M.O.W.)

**751** CONTINUUM RADIATION OF OXYGEN AND NITROGEN FOR USE IN PLASMA TEMPERATURE DETERMINATION. Morris, J. C.; Krey, R. U.; Bach, G. R. (Avco Corp., Wilmington, Mass.). 28p. (CONF-660611-8). ORAU. Gmelin, AED-CONF-66-172-10.

From Society of Applied Spectroscopy Meeting, Chicago.

The temperature dependence of the continuum radiation from 9000°K to 14,000°K of oxygen and nitrogen at 4348 and 4955 angstroms respectively was measured with sufficient accuracy to permit it to be used as a convenient and accurate means of measuring plasma temperatures. These data were analytically treated to separate the continuum into the contribution of electron-neutral and electron-positive ion radiative processes and were compared with and found to be in satisfactory agreement with recent theoretical estimates. Based upon this agreement, tables were constructed for the temperature dependence of the continuum radiation of oxygen and nitrogen from 9000 to 18,000°K and for pressures ranging from 0.1 to 5.0 atmospheres. (auth)

**752** RESPONSE OF A CYLINDRICAL PROBE TO A PLASMA WAVE. Fontheim, E. G. (Univ. of Michigan, Ann Arbor). 24p. (CONF-660443-5). ORAU. Gmelin, AED-CONF-66-142-16.

From International Scientific Radio Union Conference, Washington, D. C.

The response of a cylindrical Langmuir probe to an incident plane plasma wave was calculated for frequencies above, but near, the plasma frequency. The wave vector k of the incident wave is considered to be normal to the axis of the probe. The behavior of the plasma is described by the linearized Vlasov equation, and k is taken to be real, while $\omega$ is complex. Using typical F-region parameters, calculations were performed to obtain the collected rf current to be expected in the ionosphere. (auth)

**753** WITH WHAT PRECISION CAN SURFACE WAVES BE USED TO MEASURE AVERAGE ELECTRON DENSITY? Carlile, R. N.; Spiegel, R. J.; Swinford, H. W. 11p. (CONF-660419). ORAU. Gmelin, AED-CONF-66-057-4.

From IEEE Region 6 Annual Conference, Tucson, Ariz.

It is shown that the method of measuring average electron density in a plasma by means of electron surface waves is as good as, or better, than other methods. A simple measuring apparatus is described and it is shown that average plasma frequency can be measured to within an error of about 5%. (auth)

## *Kinetics of Plasma*

*Refer also to abstracts 577, 661, 676, 743, 752, 800, and 812.*

**754** (AD-631339) TIME BEHAVIOR OF MULTIPLE SCATTERING. Rosen, B.; Ruffine, R. S. (Radio Corp. of America, Moorestown, N. J. Missile and Surface Radar Div.). Dec. 1965. Contract AF19(628)-5167. 34p. (ESD-TDR-66-44). CFSTI $3.60 cy, $0.50 mn.

For Lincoln Lab., Massachusetts Inst. of Tech., Lexington.

Cross-polarized electromagnetic backscatter from a cylinder of underdense plasma is considered when the input is a rf pulse of finite duration. The second Born approximation is employed. The dimensions of the scatterer are assumed large compared with the rf wavelength and the correlation distance. For times sufficiently long after the pulse has ended, the "cross section" is shown to fall off as the reciprocal of the time squared. An estimate is made of the effect of a non-uniform electron density and it is found that, provided the rate of decay is not too great, the cross-polarized backscatter and the directly polarized backscatter arise from the same volume of the scatterer. (auth)

**755** (AD-631569) INTERACTIONS OF AN ELECTRIC ARC PLASMA WITH TRANSVERSAL MAGNETIC FIELDS AND GAS FLOWS. Scientific Summary Report, June 1, 1964-November 30, 1965. Fischer, E.; Fucks, W.; Uhlenbusch, J. (Technische Hochschule, Aachen (West Germany)). Contract AF61(052)-805. 28p. (ARL-66-0077). CFSTI $2.60 cy, $0.50 mn.

Calculation is made of the temperature distribution and the flow field in a wall stabilized arc, which is burning in a constant magnetic field perpendicular to the arc axis. The interactions of an arc plasma with an external gas flow are treated for the column of a free burning arc exposed to a homogeneous flow of cold or preheated gas perpendicular to the arc axis, that is to the line between the electrodes. The arc fluctuate, the flow field and the temperature distribution are calculated. (TAB)

**756** (AD-631694) MULTI-FLUID ANALYSIS OF WAVE PROPAGATION IN A MAGNETOPLASMA. Final Report, January 27-December 31, 1965. Sodek, B. A. Jr.; Gibson, D. M.; Brigman, G. H. (General Dynamics/Fort Worth, Tex.). Mar. 23, 1966. Contract AF49(638)-1428. 135p. (AFOSR-66-0692; FZM-4609). CFSTI $4.00 cy, $1.00 mn.

A theoretical investigation was made to determine the propagation characteristics of small amplitude, hydromagnetic waves in a magnetoplasma-filled waveguide at signal frequencies approximately equal to or less than the ion-cyclotron frequency. An inviscid, quasi-one-fluid analysis was made which includes the effects of Hall field. A more complex analysis was made which incorporated the effects of unequal electron and ion temperatures, space charge, diffusion, and current inertia. The method of approach was then generalized to permit treatment of neutral particle dynamics. This included partial ionization of the plasma and the existence of a sheath of neutral particles at the walls of the waveguide. A numerical study was also conducted to establish the significance of multi-fluid effects on the phase velocity, attenuation, cutoff frequency (where pertinent), and wave patterns. (auth)

**757** (AD-631844) COUPLING OF WAVES IN A HOT INHOMOGENEOUS ANISOTROPIC ELECTRON PLASMA. Scientific Report No. 2, June 1-November 30, 1965. Lonngren, K. E.; Sjolund, A.; Weissglas, P. (Kungliga Tekniska Hogskolan, Stockholm (Sweden)). Jan. 20, 1966. Contract AF61(052)-895. 19p. (RADC-TR-66-187). CFSTI $1.00 cy, $0.50 mn.

The coupling of waves in a region of varying density in a hot anisotropic electron plasma is studied theoretically. The influence of the width of the inhomogeneous region and of the angle between the propagation vector and the static magnetic field are investigated. The latter parameter is shown to be very important. (auth)

**758** (AD-632422) TWO-TEMPERATURE THEORY FOR A HELIUM ARC PLASMA IN A CYLINDRICAL DUCT. Pytte, Agnar; Winsor, Niels K. (Dartmouth Coll., Hanover, N. H.). 1965. Contract AF33(657)-8179. 15p. (ARL-66-0047). CFSTI $1.00 cy, $0.50 mn.

A simple theoretical model with different electron and heavy particle temperatures is applied to a high pressure helium arc in a cooled cylindrical duct. Single temperature theories predict a universal curve independent of duct radius for dissipated power versus the product of the axial electric field and the duct radius. The experimentally measured deviations from this universal curve are explained by the two temperature theory. The current-voltage characteristic of a cylindrical wall segment probe is also understood in terms of an elevated electron temperature, often exceeding the heavy particle temperature by an order of magnitude near the wall. (auth)

**759** (AD-632541) NUMERICAL CALCULATIONS OF FIELDS AND DISPERSION CURVES FOR A HOT, INHOMOGENEOUS CYLINDRICAL PLASMA. Scientific Report No. 5, June 1, 1965-January 15, 1966. Sjogren, L. (Kungliga Tekniska Hogskolan, Stockholm (Sweden)). Jan. 25, 1966. Contract AF61(052)-895. 25p. (RADC-TR-66-304). CFSTI $1.00 cy, $0.50 mn.

A method for the numerical solution of the system of differential equations describing the electric field in a cylindrical plasma surrounded by a metal shield, was developed. The plasma is hot, inhomogeneous and situated in a constant magnetic field. The method was applied to a case with wave propagation and magnetic field both parallel to the axis of the cylinder. Numerical solutions for the inhomogeneous plasma have, as yet, been obtained only for test purposes, as the program construction has just been completed. A preliminary study of the plasma with constant electron density was made for the mode which has axial symmetry. (auth)

**760** (AD-634287) SINGLE PULSE RESPONSE OF A PLASMA. Gould, Roy W. (California Inst. of Tech., Pasadena). May 1966. Contract Nonr-220(50). 10p. CFSTI $1.00 cy, $0.50 mn.

The conjecture by Hirschfield and Wachtel that a weak pulse of radiation can trigger the emission of a large delayed burst of coherent electron cyclotron radiation is

examined critically. The effect is found to exist when the electrons have a single velocity perpendicular to the magnetic field, but disappears in a thermal equilibrium distribution. (auth)

**761** (AD-634634) SELF-FOCUSING OF INTENSE BEAMS OF RELATIVISTIC ELECTRONS. Roberts, T. G. (Army Missile Command, Redstone Arsenal, Ala.). June 1966. 14p. CFSTI $1.00 cy, $0.50 mn.

It is shown that a beam of relativistic electrons can be extracted from the electrode space of an x-ray machine, and that these electrons will form a Bennett pinch or at least will not blow up when they enter an ionized medium. The pinched beam of electrons will travel more than 23 centimeters without blowing up, while an electron beam such as this when projected in vacuum blows up drastically in less than 2 centimeters. (TAB)

**762** (AD-635155) PULSE STIMULATED RADIATION FROM A PLASMA AT HARMONICS OF THE GYROFREQUENCY. Kegel, Welhelm H. (California Inst. of Tech., Pasadena). June 1966. Contract Nonr-220(50). 26p. (TR-32). CFSTI $1.00 cy, $0.50 mn.

A magnetoplasma excited by two short pulses at the gyrofrequency or a multiple thereof, is considered in the single particle approach. After the second pulse, radiation maxima arise at the gyrofrequency and its harmonics. In a situation where the time separation of these maxima is $\tau^*$ (in the simplest case $\tau^* = \tau$) at the fundamental, it is $\tau/n$ at the n-th harmonic. As the resonances at the harmonics are a finite Larmor radius effect, excitation at these frequencies requires an initial energy. As an example, the case is studied where the first pulse has the gyrofrequency while the second has the frequency 2 ($\omega$-c). In this case radiation maxima arise with 2 ($\omega$-c) at times $t_L = L(\tau)$ (l = 1,2,3, ...) after the second pulse. At the fundamental the maxima arise at times $t_L = (2l-1)\tau$, where the maximum at the time $\tau$ is initially due to the nonlinearity during the second pulse. (auth)

**763** (AD-636395) OBLIQUE WAVE PROPAGATION IN DRIFTING ISOTROPIC HOT PLASMA. Unz, H. (RAND Corp., Santa Monica, Calif.). Sept. 1965. 27p. (P-3223 (RAND)). CFSTI $2.00 cy, $0.50 mn.

The electromagneto-plasma-gas-dynamic equations are summarized for hot, compressible electron gas, with no magneto-static field, drifting with a constant velocity. Using small signal theory for oblique plasma wave propagation, a determinantal equation for the refractive index is found and is applied for particular cases. (auth)

**764** (AD-636493) OBLIQUE INCIDENCE ON A SEMI-INFINITE COMPRESSIBLE GENERAL MAGNETO-PLASMA. Unz, H. (RAND Corp., Santa Monica, Calif.). Aug. 1965. 27p. (P-3189(RAND)). CFSTI $1.00 cy, $0.50 mn.

The problem of a plane electromagnetic wave with arbitrary polarization incident obliquely on a semi-infinite compressible general magnetoplasma was solved and the corresponding reflection and transmission coefficients were evaluated. (auth)

**765** (AD-636581) RADIATION FROM ELECTROMAGNETIC SOURCES IN AN UNBOUNDED COMPRESSIBLE MAGNETO-PLASMA. Unz, H. (RAND Corp., Santa Monica, Calif.). Sept. 1965. 25p. (P-3224 (RAND)). CFSTI $1.00 cy, $0.50 mn.

The radiation fields from electric and magnetic current density sources, arbitrarily distributed in unbounded compressible plasma with arbitrarily directed static magnetic field, are evaluated by using Fourier integral transform. The final results are expressed in terms of dyadic Green's functions. (auth)

**766** (JPRS-36717) PLASMA AND ELECTRONIC SUPER-HIGH FREQUENCY AMPLIFIERS AND OSCILLATORS. Bernashevskii, G. A.; Bogdanov, E. V.; Kislov, V. Ya.; Chernov, Z. S. Translated from pp 1-96 of Plazmennye i Elektronnye Usiliteli i Generatory SVCh, Izdatel'stvo Sovetskoe Radio, Moscow, 1965. 83p. (TT-66-33148). CFSTI $3.00 cy, $0.75 mn.

An abstract for this book appeared previously in NSA as 20: 29500. (M.O.W.)

**767** (SC-T-66-0747) STUDY OF THE THERMAL CONDUCTIVITY AND OF THE VISCOSITY OF AN IONIC CURRENT ACCORDING TO THE GRAD METHOD. Do, Claude. Translated by Walter Scheurle (Sandia Corp., Albuquerque, N. Mex.), from J. Mec., 2: 301-11(1963). 13p. Dep. mn. JCL $1.60 fs, $0.80 mf.

H. Cabannes earlier solved the problem with the method of Enskog by starting with the hypothesis that the distribution function of the velocities was near to a local Maxwell distribution. An analysis was made for the solution in the form of a development in series of Sonine-polynomials — functions of the module of the agitation velocity which are going at a linear system and comprise an infinity of unknowns (the coefficients of the development in series of Sonine-polynomials). These coefficients were then considered to be zero at the beginning of a certain order N. An attempt was made to find the solution f of the Boltzmann equation by means of the method of H. Grad in the form of a development in series of Hermite polynomials — functions of the agitation velocity. The equation of Boltzmann should then furnish one with an infinity of equations for the coefficients of Hermite. Then the equations of moments were linearized by assuming certain small quantities. (M.O.W.)

**768** THEORY OF CHERENKOV COUPLING TO BEAM-PLASMA SYSTEMS. Vlaardingerbroek, M. T.; Wierda, G. (Philips Research Labs., Eindhoven, Netherlands). Electron. Lett., 2: 368-70(Oct. 1966).

Using a simple mathematical model, the theory of Cherenkov radiation of a beam-plasma system into a dielectric is discussed. The complete system can be divided into two subsystems — the dielectric-loaded waveguide and the beam-plasma system — which mutually couple according to the laws of the mode-coupling theory. (auth)

**769** CHERENKOV COUPLING TO BEAM-PLASMA SYSTEMS. Weimer, K. R. V.; Bodt, H. (Philips Research Labs., Eindhoven, Netherlands). Electron. Lett., 2: 368(Oct. 1966).

Experiments with a beam-plasma amplifier, in which the input coupler is a cavity and the output coupling is due to Čerenkov radiation from the beam-plasma system into a dielectric, is discussed. The overall gain of the tube was 15dB at 10GHz. The Cherenkov effect was also used to couple an electromagnetic signal into the beam-plasma system. (auth)

**770** LOW-CURRENT BEAM-PLASMA EXPERIMENTS WITH A BEARING ON TURBULENCE. Emeleus, K. G.; Jones, J. M.; Kennedy, W. T. (Queen's Univ., Belfast). Electron. Lett., 2: 359(Oct. 1966).

Experiments are described and discussed on the excitation by low-voltage electron beams of plasma electron and ion oscillations in almost the whole acoustic-to-gigahertz frequency range, and on the reaction of these on single and double beams and on one another, which provide examples of the development and nature of turbulence in the generalized sense in which this is now understood. (auth)

**771** PLASMA THERMAL CONDUCTIVITY WITH COLLECTIVE EFFECTS. Rand, S.; Levinsky, E. S. (Univ. of California, La Jolla, San Diego). Phys. Fluids, 9: 1991-6(Oct. 1966).

The electron thermal conductivity of a fully ionized Lorentz gas was studied. The energy transfer among regions of the gas at different local temperatures was determined by considering the emission and absorption of longitudinal plasma waves. These waves are both collision and Landau damped; the latter type of damping effects the energy transfer only secondarily, since the resulting energy does not go directly into the heating of the gas. The results obtained by assuming infinite Landau damping are expected to agree with typical two-body collision treatments. However a nonvanishing plasma parameter, which results in finite Landau damping, facilitates the introduction

of a variety of collective effects. Thus, it is found that, beyond the dependences obtained in conventional two-body collision studies, the thermal conductivity exhibits an additional weak dependence on the plasma parameter. (auth)

**772** EFFECT OF RESONANT CHARGED EXCHANGE ON HEAT CONDUCTION IN PLASMAS. Mason, E. A. (Univ. of Maryland, College Park); Sherman, Martin P. Phys. Fluids, 9: 1989-91(Oct. 1966).

Estimates are made of cross sections for symmetric resonant charge exchange between ions differing by one electronic charge. At thermal energies and electron densities of interest, these cross sections are negligible compared to the elastic screened Coulomb cross section for diffusion. It is concluded that resonant charge exchange between ions cannot affect heat conduction in plasmas by controlling the rate of diffusive transport of ionization energy, in contrast to ion–neutral exchange in partially ionized gases. (auth)

**773** DENSITY GRADIENT EFFECTS ON ALFVEN WAVE PROPAGATION IN A CYLINDRICAL PLASMA. McPherson, D. A.; Pridmore-Brown, D. C. (Aerospace Corp., Los Angeles). Phys. Fluids, 9: 2033-42(Oct. 1966).

The propagation of nonaxisymmetric Alfvén waves in a linear discharge tube filled with a nonuniform plasma under a 30-kG axial field was investigated theoretically and experimentally in the frequency range 1 to 5 Mc/sec. Typical plasma densities were 3 to $4 \times 10^{15}$ ions/cm$^3$ near the center of the tube and fell to low values at the wall. It was found that the density gradient introduces a frequency dependent coupling between the torsional and compressional waves of the uniform plasma. As a result, an axial component of the magnetic field perturbation, which is normally associated only with the compressional wave, is now carried by the torsional wave as well, and was in fact detected at frequencies well above the lowest waveguide cutoff of the compressional wave. At still lower frequencies, this component disappeared, and the remaining transverse field components were found to propagate at a radially varying speed which agreed well with the local Alfvén speed deduced from the measured ion density profile. A theoretical analysis is presented, and its predictions are compared with experimental measurements of signal amplitudes, wave speeds, attenuation rates, and density profiles. (auth)

**774** DIPOLAR RADIATIVE MODES OF A PLASMA CYLINDER. Bullock, D. L.; Oltman, George (TRW Systems, Redondo Beach, Calif.). Phys. Fluids, 9: 2026-32(Oct. 1966).

Radiative modes associated with a thin, infinitely long circular plasma cylinder and having dipolar azimuthal field variations are investigated. The plasma is treated as a lossless dielectric with $\epsilon = \epsilon_0(1 - \omega_p^2/\omega^2)$. No thermal effects are considered, and, contrary to the strong background magnetic field case investigated by Dawson and Oberman, no background magnetic field is introduced. The procedure requires the investigation of the dispersion equation resulting from the matching of tangential electromagnetic field components across a plasma-free space boundary, with emphasis on satisfying the radiation boundary conditions. Modes having axial phase velocities in the range $c < v_p < \infty$ are shown to exist and are analyzed. A comparison with the analog of such modes for cylinders of finite length, which have been experimentally verified, is made, indicating the utility of the infinite structure analysis in explaining the experimental results for radiative modes on finite structures. (auth)

**775** CONTRIBUTION OF ELECTRON-ELECTRON COLLISIONS TO THE EMISSION OF BREMSSTRAHLUNG BY A PLASMA. Birmingham, Thomas J. (Goddard Space Flight Center, Greenbelt, Md.); Dawson, John M.; Kulsrud, Russell M. Phys. Fluids, 9: 2014-25(Oct. 1966).

A new model for treating plasma radiation processes in plasma is extended to the problem of bremsstrahlung emission from electron–electron collisions. The spectra of longitudinal and transverse waves, including dielectric effects, are derived to lowest nonvanishing (quadrupole) order. A resonance in the spectrum of transverse waves near $\omega = 2\omega_p$, the first harmonic of the electron plasma frequency, is noted. The high-frequency form of the transverse spectrum is approximately evaluated and found to be relativistically small by comparison with the dominant electron–ion bremsstrahlung. Finite wavelength corrections to the radiation generated by electron–ion collisions are also discussed. (auth)

**776** PAIR PRODUCTION OF PLASMA VORTICES. Bostick, W. H.; Prior, W.; Grunberger, L.; Emmert, G. (Stevens Inst. of Tech., Hoboken, N. J.). Phys. Fluids, 9: 2078-80(Oct. 1966).

Image converter photographs of various interfaces between a magnetic field and an accelerated plasma show clearly the production of plasma vortex filaments in pairs. These vortex filaments fall into two classes: those parallel to $B_0$ (the background magnetic field) and those perpendicular to $B_0$. (auth)

**777** CHARACTERISTICS OF A ROTATING PLASMA. Hassan, H. A. (North Carolina State Univ., Raleigh). Phys. Fluids, 9: 2077-8(Oct. 1966).

It is shown that a simple consideration of the conservation equations of the plasma constituents explains the characteristics of a rotating plasma observed by Alfvén and Fahleson. (auth)

**778** ALTERNATIVE METHOD FOR EXCITING ELECTRON PLASMA OSCILLATIONS WITH TRANSVERSE ELECTROMAGNETIC WAVES. Montgomery, David (Univ. of Iowa, Iowa City); Alexeff, Igor. Phys. Fluids, 9: 2075-7(Oct. 1966). (ORNL-P-1998).

A shock-like excitation of electron plasma oscillations is proposed which involves no mechanical contact with the plasma. It is achieved by the nonlinear (nonresonant) action of an electromagnetic wave. (auth)

**779** HARMONIC RESPONSE DUE TO COMPRESSIBILITY IN TRAVELING WAVE PLASMA DEVICES POSSESSING CYLINDRICAL SYMMETRY. Haldeman, Charles W. (Massachusetts Inst. of Tech., Cambridge). Phys. Fluids, 9: 2074-5(Oct. 1966).

When the slip velocity between magnetic field and plasma in a traveling wave induction plasma accelerator exceeds the sonic speed, magnetoacoustic resonances are predicted by linear theory. These resonances are discussed in the case of cylindrical symmetry. (auth)

**780** DIFFRACTION BY AN IMPEDANCE HALF-PLANE IN AN ANISOTROPIC PLASMA. Breithaupt, R. W. (NRC, Ottawa). Can. J. Phys., 44: 2915-25(Nov. 1966).

The problem solved previously by Jull (1964) for a perfectly conducting half-plane is extended to the case of an impedance half-plane. As assumed by Jull, the direction of the incident wave is normal to both the magnetostatic field and the diffracting edge. The plasma is characterized by a permittivity tensor; and only the TM incident field is considered, as the anisotropy does not affect an incident TE wave. The impedance boundary condition is found to introduce unidirectional surface waves propagating at some angle into or away from the surface, as well as the usual radiated far fields. (auth)

**781** DYNAMIC DISSIPATION OF A MAGNETIC FIELD AND PARTICLE ACCELERATION. Syrovatskii, S. I. (Lebedev Inst. of Physics, Moscow). Soviet Astron.-AJ (Engl. Transl.), 10: 270-80(Sept.-Oct. 1966).

Translated from Astron. Zh., 43: 340-55(Mar.-Apr. 1966).

A dynamic dissipation mechanism for a magnetic field is proposed that can convert magnetic energy directly into fast-particle energy. Under certain conditions motion of a conducting medium will produce regions with a strong magnetic gradient and high rarefaction. The maximum current the conducting medium can provide there will be inadequate to maintain the magnetic gradient. As a result a strong magnetic field will develop and accelerate charged parti-

cles. The reserve of excess magnetic energy will be transformed into the kinetic energy of the fast particles. Application of criteria that are derived indicates that dynamic-dissipation conditions may be realized in solar chromospheric flares, turbulent supernova envelopes, exploding galactic nuclei, radio galaxies, the earth's magnetosphere, and in certain laboratory experiments. In these objects dynamic dissipation may be the chief mechanism for accelerating particles to high energies, and in particular for generating cosmic rays. (auth)

**782** GUIDED WAVES SUPPORTED BY LAYERS OF A LOSSY COMPRESSIBLE PLASMA. Galejs, Janis (Sylvania Electric Products Inc., Waltham, Mass.). Can. J. Phys., 44: 2875-91(Nov. 1966).

A planar slab of isotropic compressible lossy plasma is bounded either by free space on both sides or by free space and a ground plane, and is excited by line sources. After the dispersion relations were established, the power carried by the waves was calculated. The total power of the many waves which depend on the resonances of the plasma waves in the transverse dimension of the slab is about two orders of magnitude lower than the power of the surface waves guided along the plasma boundary for frequencies which are somewhat higher than the plasma frequency. The excitation efficiency of the transversely resonant waves is decreased for thick layers of a lossy plasma, but the losses can be neglected if the layer thickness is of the order of the free-space wavelength and the loss tangent of the plasma is less than 0.01. (auth)

**783** COLLISIONLESS SHOCK WAVES IN HOT PLASMAS. Sakagami, Yukio; Yamanaka, Chiyoe. Technol. Rep. Osaka Univ., 16: 153-62(Mar. 1966).

Experimental results concerning collisionless shock waves were studied. In a preionized magnetoplasma produced by a linear discharge, a hot plasma was driven by a conical gun. In this case a shock structure was observed, the width of which (2 cm) was much smaller than the collisional mean free path (30.2 cm) behind the running front. Applying strong magnetic obstacles in a stream, the standing magnetohydrodynamic shock waves appeared. (auth)

**784** INVESTIGATIONS ON A SUPERSONIC PLASMA JET WITH AXIAL CURRENT. Ragaller, Klaus (Technische Hochschule, Munich). Z. Naturforsch., 21a: 1260-9(Aug. 1966). (In German).

Starting from a parallel jet concept the linearized magnetogasdynamic equations are solved for a supersonic free plasma jet with an axial current. The solution is given in terms of the magnetic pressure number. A critical magnetic pressure number depending on the Mach number is derived. Below this value standing periodic pressure waves occur, as in the gasdynamic case. For higher values the pressure distribution is nonperiodic. Experiments are performed with a supersonic argon jet. The Mach number is determined by the shock angle at a cone. The pressure distribution in the axis of the jet is measured by a pressure probe. The experimental results are consistent with the theoretical predictions. (auth)

**785** ANOMALOUS COLLISIONLESS DAMPING OF ALFVEN WAVES IN INHOMOGENEOUS PLASMAS. Winterberg, F. (Univ. of Nevada, Reno). Z. Naturforsch., 21a: 1270-84(Aug. 1966).

It is shown that Alfvén waves in a collisionless plasma, permeated by an inhomogeneous magnetic field, are affected by a strong anomalous damping. This anomalous collisionless damping seems to correspond to collision-free Landau damping in homogeneous magnetic fields in a similar way as the anomalous viscous and ohmic damping of Alfvén waves propogating in inhomogeneous magnetic fields corresponds to the ordinary collisional viscous and ohmic damping of Alfvén waves propagating in homogeneous magnetic fields. It is found that the predicted collision-free anomalous damping will obey a law of the form $\exp\{-(t/\tau)^2\}$ where the damping time $\tau$ depends on the wave-length, the temperature of the plasma, and the magnetic field gradient. Starting from a simplified Boltzmann–Vlasov equation, valid for low frequency plasma waves, a Laplace transform is carried out with regard to the time dependence and an integral equation is derived for the mean plasma velocity. By the Faltung theorem this integral equation can be Fourier transformed into a differential equation for which a W.K.B. solution can be obtained. The inverse transforms can be carried out by making a simple analytic approximation for the W.K.B. solution which is valid over a large range of values. The predicted anomalous damping of Alfvén waves is so strong that it may be useful for the purpose of heating a plasma up to high temperatures within a short time. (auth)

**786** INFLUENCE OF TEMPERATURE ON THE DEGREE OF INHOMOGENITY OF THE ARC PLASMA AND ON THE CALIBRATION CURVES DISPLACEMENT. Ovechkin, G. V.; Bakhtovarshoev, Sh.; Sandrigailo, L. E. Zh. Prikl. Spektrosk., Akad. Nauk BSSR, 5: 16-22(July 1966). (In Russian).

An enhancement of the inhomogeneity degree of the arc plasma was found experimentally. Increasing differences in the evaporation rates of elements were observed at higher temperatures, the other discharge conditions remaining the same. With increasing plasma inhomogeneity the effect of line self-reversal increases leading to an intensity decrease of lines emitted as a result of transitions to the ground state or to low excited metastable states. The previously proposed method may be applied to the self-reversed lines by introducing a corresponding factor in the classical intensity formula. (auth)

**787** TO THE PROBLEM OF ELECTROMAGNETIC WAVE SELF-FOCUSING IN ANISOTROPIC NONLINEAR MEDIA. Litvak, A. G. (Gorkii State Univ., USSR). Izv. Vyssh. Ucheb. Zaved., Radiofiz., 9: 629-31(1966). (In Russian).

A generalized self-localized solution is found for the simple anisotropic medium which is represented by plasma in a strong magnetic field. It is shown that the condition $\partial\epsilon/\partial|E|^2 > 0$ for the dielectric penetrability tensor component is not sufficient for resolving the problem. Moreover, self-focusing of waves is also possible in an anisotropic medium with ionizing nonlinearity. (R.V.J.)

**788** HYDRODYNAMIC ACCELERATION OF A PLASMA IN A DISCHARGE TUBE. Fadeev, S. I. Inzh. Zh., 5: 950-4(1965). (In Russian).

An investigation was made of the one dimensional plane motion of a non-viscous, non-heat-conducting ideal gas, determined by the evolution of energy (per unit of area) according to the law: $W = W(t)$, $W(0) = 0$, where $W(t)$ is a continuous function, together with its derivatives. The problem reduces to the solution of the problem of a piston, the law of whose motion is connected with the above equation by an equation expressing the conservation of energy. (ATD)

**789** APPROXIMATE THEORY OF MICROWAVE INTERACTION WITH BOUNDED GYROTROPIC MEDIA. Nagelberg, Elliott R. (Bell Telephone Labs., Inc., Whippany, N. J.). 21p. (CONF-660443-3). ORAU. Gmelin, AED-CONF-66-142-15.

From International Scientific Radio Union Conference, Washington, D. C.

The analysis is confined to a lossless plasma in which a uniform static magnetic field is maintained. The general theory is reviewed together with the calculations necessary for determining the first-order fields, which are linear in the ratio $\omega_p/\omega$. The second-order analysis is then presented, first in general terms without reference to a specific coordinate system. An explicit solution is then given in terms of spherical coordinates, for application to appropriate boundary value or radiation problems. Finally, the general problem is considered and solutions are presented for the nth-order scalar functions, from which the electromagnetic fields may be generated by appropriate vector operations. (M.O.W.)

**790** RESONANCES IN THE IONOSPHERE MAGNETOPLASMA. Johnston, T. W.; Shkarofsky, I. P. (RCA Victor Co., Ltd., Montreal). 4p. (CONF-651146-1). ORAU, Gmelin, AED-CONF-65-349-9.

From 2nd American Astronautical Symposium, Coral Gables, Fla.

ALOUETTE, the swept-frequency topside-ionosphere sounding satellite, detected ringing, evident as "spikes," on ionograms at certain frequencies. These ringing phenomena proved to be the local plasma frequency, the transverse resonance frequency, and harmonics (up to the fifteenth) of the cyclotron frequency. Collisions being negligible, the classical Vlasov electron plasma dispersion equation is applicable, from which these particular ringing frequencies are easy to infer; but the complicating effects of orientation, antenna size, time behavior, etc., require and are now undergoing advanced theoretical analysis. The ALOUETTE low-frequency noise receiver also detected characteristic frequency phenomena involving ions associated with the electron-ion hybrid frequency and the zero-gyration electron–ion frequency. This work is summarized and a bibliography of the pertinent literature in the field is included. (auth)

**791** THEORY OF THE LINEAR FOKKER-PLANCK COLLISION OPERATOR. Su, C. H. (Massachusetts Inst. of Tech., Cambridge). 28p. (CONF-651126-29). ORAU, Gmelin, AED-CONF-65-353-70.

From American Physical Society, 7th Annual Meeting of the Division of Plasma Physics, San Francisco.

The linearized Fokker–Planck collision integral with Coulomb interaction is expanded in terms of surface spherical harmonics. The radial part of the distribution function is shown to be governed by a set of decoupled differential-integral equations. The differential operators are shown to be self-adjoint while the integral operators are symmetric and completely continuous. The spectrum of the eigenvalues contains, on top of discrete points, a continuous part ranging from zero to minus infinity. The discrete part of the spectrum is obtained by requiring that the corresponding eigenvectors have a definite asymptotic behavior at large velocity. A variation principle is constructed for the computation of the discrete spectrum. (auth)

## *Production of Plasma*

**792** (AD–629496) STUDY OF TRANSIENT PHENOMENA IN LOW PRESSURE GAS DISCHARGE PLASMAS. Quarterly Report No. 7, August 3, 1965–November 3, 1965. Derfler, Heinrich (Stanford Univ., Calif. Inst. for Plasma Research). Dec. 1965. Contract AF 33(615)-1504. 21p. (ARL–65-276). CFSTI $2.60 cy, $0.50 mn.

The electric field excited in a Maxwellian electron plasma by a pair of closely spaced grids was calculated by three methods, numerical evaluation of the cosine integral expression, summation of the plasma wave functions and the Bohm and Gross wave approach. It is shown that the higher order modes, although damped, are excited sufficiently to be important and account for any difference between the first two methods. (auth)

**793** (AD–635761) THE CALCULATION OF CHEMICAL AND IONIZATION EQUILIBRIUM IN A CONVENTIONAL SHOCK TUBE. Rich, John C. (Harvard Coll. Observatory, Cambridge, Mass.). July 1966. Contract Nonr-1866(48). 32p. CFSTI $2.00 cy, $0.50 mn.

The equations describing a plasma in local thermodynamic equilibrium are presented and applied to a conventional shock tube. If conditions of local thermodynamic equilibrium exist, these equations give the number densities of the atoms, molecules, ions and electrons that make up the plasma. For practical results an effective iteration scheme is presented for the computer solution of such equations. (auth)

**794** (AD–635872) EFFECTS OF MECHANICAL AND THERMAL ELECTRODE PROPERTIES ON THE BEHAVIOR OF THE FLUID TRANSPIRATION ARC. Final Technical Report, November 1, 1963–October 31, 1964. Sheer, C.; Tschang, P. S.; Stojanoff, C. G. (Columbia Univ., New York. Electronics Research Labs.). Aug. 1965. Contracts AF33(615)-1141; AF49(638)-1395. 146p. (ARL–65-163). CFSTI $4.00 cy, $1.00 mn.

A triple cathode, single anode arc assembly, designed to produce a symmetrical free-burning plasma jet, was completed and placed into operation. A second arc assembly with a single gas-injection cathode, was also constructed for the double purpose of testing porous anodes and accelerating the acquisition of diagnostic data. Diagnostic instrumentation was developed, based on high speed transient probing with miniature sensing elements. Work was carried forward on the development of porous anodes. Diagnostic experiments include measurements of arc terminal characteristics, current density distribution, temperature variations, potential distribution, plasma luminosity distribution and calorimetry experiments. The influence of forced convection into the negative column near the cathode was separately investigated. A two-dimensional computer analysis of transpiration cooling of the porous anode was worked out. (auth)

**795** (AD–636182) CHEMICAL RELEASE STUDIES. V. RECOMBINATION DURING RADIAL FREE EXPANSION OF A PLASMA SPHERE. Berger, A. W.; Golomb, D. (Geophysics Corp. of America, Bedford, Mass.). Jan. 1961. Contract AF19(604)-7269. 26p. (AFCRL–202). CFSTI $2.60 cy, $0.50 mn.

Smith's analysis of ion-electron recombination in nozzle flow is adapted to radial free expansion of a plasma sphere. A "peeling onion" model is developed: the plasma ball sheds outer layers from an undisturbed core until the center is reached. Each layer in turn serves as a steady state source for the expanding gas. A family of curves of the degree of ionization vs reduced time for the retreating layers is obtained. The degree of ionization asymptotically approaches a quenched value, beta infinity (r). Evaluation of beta infinity (r) vs the radii of the source layers indicates that the degree of ionization increases from the edges of the expanding plasma toward the center. The fraction of ions quenched is determined by integration over the volume elements. The recombination of iodine (in argon carrier) released by shattering glass spheres is suggested as an experimental test of the expansion model. (auth)

**796** (LRP–27/66) CONFINEMENT D'UN PLASMA PAR CHAMP TOURNANT. LA STABILITE DU SYSTEME GENERATEUR-PLASMA. (Plasma Confinement by a Rotating Field. Stability of Plasma-Generating System). Weibel, Erich S. (Laboratoire de Recherches sur la Physique des Plasmas, Lausanne (Switzerland)). Aug. 1966. 14p. Dep. mn.

The rf generators supplying the power to build up the confining fields and to heat the plasma are coupled to the latter optimally as described previously. The low-frequency stability of this system is analyzed, taking into account the increase in time of the plasma temperature and of the field amplitude. The system is shown to be stable. (auth)

**797** (N–66-23848) BASIC STUDIES ON VORTEX STABILIZED RADIATION SOURCES FOR IMPROVED SOLAR SIMULATION. Van Ornum, Delbert G. (Giannini Scientific Corp., Santa Ana, Calif.). May 1966. Contract NASw-858. 99p. (NASA-CR–468). CFSTI $3.00 cy, $0.75 mn.

The ultimate objective was to improve the simulation of the solar spectrum as observed in space. The discrepancies between the spectral energy distribution found in argon vortex arc radiation and the zero air mass solar radiation were studied. To improve the spectrum, various elements were selected and added to the arc so that their broadened line radiations would fill in deficient zones. The additives were gases, or solid compounds injected into the arc itself and filtered out of the gas stream before recirculation. Measurement of the spectal output of the argon arc with injected titanium, barium, sodium, hydrogen, lantha-

num, and mercury led to a better understanding of both line and continuum radiation physics. From the line radiation approach, improved simulation of the solar spectrum was obtained by adding small amounts of hydrogen and barium to the argon vortex. From the continuum approach, excellent simulation was achieved by use of pure xenon in a high pressure vortex arc. (STAR)

**798** (NP-16358) PRECURSOR RADIATION IN ELECTROMAGNETIC SHOCK TUBES. Technical Report No. 4. Scotto, Michael J.; Kerr, Donald E. (Johns Hopkins Univ., Baltimore, Md. Dept. of Physics). Sept. 1966. Contract Nonr-4010(10). 83p.

Thesis. Submitted by Michael J. Scotto.

Precursor phenomena were investigated in an electromagnetic shock tube having a cylindrical driver section. Pre-excitation of the cold gas ahead of the main luminosity front was examined through spectroscopic analysis of optical precursor radiation and microwave measurements of the electron density. This investigation was made to determine the origin and magnitude of pre-excitation in a shock tube with a cylindrical geometry, and to determine whether a sufficient amount of energy is transferred to the cold gas to account for the observed discrepancies. The populations of radiative excited states in a helium filled shock tube were determined from absolute intensity measurements of the precursor radiation. Estimates of the populations of metastable states were obtained from optical absorption measurements, and from measurements of optical radiation arising from a resonant transfer of excitation to an impurity gas. (M.O.W.)

**799** IONIZATION RATE OF AIR BEHIND HIGH-SPEED SHOCK WAVES. Wilson, J. (Avco-Everett Research Lab., Everett, Mass.). Phys. Fluids, 9: 1913-21 (Oct. 1966).

Measurements were made of the ionization rate of air behind strong shock waves for shock velocities between 9 and 12.5 mm/$\mu$sec. The electron density behind the shock was determined from the infrared emission around 6 $\mu$, this radiation being predominantly free-free bremsstrahlung. It was concluded that at shock speeds below 9.5 mm/$\mu$sec the predominant ionization mechanism is the reaction, $N + O \rightarrow NO^+ + e$, as postulated by Lin and Teare for slower shock speeds. However, for shock speeds above 9.5 mm/$\mu$sec, electron impact becomes the predominant ionization mechanism. (auth)

**800** KINETIC MODEL FOR THREE-COMPONENT PLASMAS WITH IONIZATION. Hu, Pung Nien; Ziering, Sigi (Space Sciences, Inc., Waltham, Mass.). Phys. Fluids, 9: 1983-8(Oct. 1966).

Ionization processes are usually introduced into the equations of magnetohydrodynamics as gross parameters to be determined by experiment. The mathematical accessibility of model kinetic equations in neutral and ionized gases motivates the formulation of kinetic equations for a three-component plasma which incorporate the ionization process in this study. As a first attempt, only the ionization processes resulting from electron-neutral collisions are considered. The resulting mathematical formalism yields a set of model equations which are mathematically not more complicated than those for plasmas without consideration of ionization. The possible application of the present model equations to various problems is discussed, such as the ionization growth in a gas, the cathode sheath, and the structure of an ionizing shock wave. (auth)

**801** HIGH-TEMPERATURE PLASMAS PRODUCED BY LASER BEAM IRRADIATION OF SINGLE SOLID PARTICLES. Haught, Alan F.; Polk, Donald H. (United Aircraft Research Labs., East Hartford, Conn.). Phys. Fluids, 9: 2047-56(Oct. 1966).

The focused 20-MW giant pulse beam of a Q-spoiled ruby laser was used to form a high-temperature, high-density plasma from a single 10- to 20-$\mu$-diam solid particle of lithium hydride suspended by a set of ac electric fields in a vacuum environment. Charge collection measurements show that total ionization of the $10^{15}$ atoms in the lithium hydride particle is achieved in the plasma produced. Time-of-flight studies of the expanding plasma yield plasma energies of more than 100 eV. Measurements were carried out which show that the mass and energy density of the expanding plasma are isotropically distributed in space. The results obtained are in good agreement with a simple model of the plasma formation and expansion. Further studies of these laser-irradiated, single particle plasmas are in progress and include measurements of the lifetime of the plasma in magnetic confinement fields. (auth)

**802** IMAGE CONVERTER OBSERVATIONS OF THE DEVELOPMENT OF THE DENSE PLASMA FOCUS DISCHARGE. Mather, J. W.; Williams, A. H. (Los Alamos Scientific Lab., N. Mex.). Phys. Fluids, 9: 2080-2(Oct. 1966). (LA-DC-7870).

A multiplicity of radial striated light filaments is observed at the back plate of the dense plasma focus coaxial discharge during the early phases of breakdown and current sheath buildup. Later in time, the current sheath appears azimuthally symmetric. (auth)

**803** STABILIZATION OF TORCH DISCHARGE. Goryaga, G. I.; Kuzovnikov, A. A.; Ruban, A. A.; Yaramyshev, G. S. Vestn. Moskov. Univ., Ser. III: Fiz. Astron., No. 6, 80-2(Nov.-Dec. 1965). (In Russian).

The high-frequency discharge, used for the generation of plasma jets, allows to attain gas stream temperatures of the order of $10^4$°K. The chief advantage of the method lies in the avoidance of the contamination of the plasma. On this basis, a new system of plasma heating in a torch discharge was developed; it involves creation of the plasma by the vibratory motion of the electrons in the high-frequency field. Discharge occurs whenever there is a slightly perturbed gas zone near the electrode. It was assumed that a radial compression of the combustion region of the torch stabilizes the discharge and increases the temperature, generating a pure plasma jet. Constructional details of the device developed for creating the high-frequency discharge are presented; an air stream was used with good success for stabilizing the jet. (TTT)

**804** EXPANSION RATES OF THE LUMINOUS FRONT OF A LASER-PRODUCED PLASMA. Weichel, Hugo; Avizonis, P. V. (Air Force Weapons Lab., Albuquerque, N. Mex.). Appl. Phys. Lett., 9: 334-7(Nov. 1, 1966).

The expansion velocity of the luminous front of a plasma plume created by a giant pulse laser was measured both as a function of time during the laser pulse and as a function of position in front of the pyrolitic graphite target. The initial velocity of the vapor appears to agree with the sublimation temperature of pyrolitic graphite. The subsequent vapor absorption of laser radiation produced peak final expansion velocities of $7 \times 10^6$ cm/sec. The luminous front was found to accelerate from $4.8 \times 10^5$ to $7.0 \times 10^6$ cm/sec within a 0.3-cm distance for a laser energy density of 700 J/cm$^2$. (auth)

**805** OBTAINING AND INVESTIGATING A STATIONARY THERMAL AIR PLASMA IN A WIDE RANGE OF PRESSURES AND TEMPERATURES. Shimanovich, V. D.; Kiselevskii, L. I. Zh. Prikl. Spektrosk., Akad. Nauk BSSR, 5: 3-7(July 1966). (In Russian).

An arrangement is described for obtaining at various pressures a high stable axis-symmetrical thermal arc cord with composition determined by the initial composition of the working gas. The radial temperature profile of the cord was studied in the pressure range of 0.20 to 6 atm. At 10 A current, the temperature in the axis region of the air cord ranged from 15,000 to 20,000°K, depending on the pressure. At the distance 0.4 to 0.5 mm from the discharge axis the temperature decreased to 5000°K. (auth)

**806** HIGH PRESSURE ARC DISCHARGES WITH TEMPERATURES IN THE REGION ABOVE 100,000 DEG K. Witkowski, S. (Institut fuer Plasmaphysik GmbH, Garching, Ger.). 14p. (CONF-651126-30). ORAU. Gmelin, AED-CONF-65-353-72.

From American Physical Society, 7th Annual Meeting of the Division of Plasma Physics, San Francisco.

The so-called high-pressure arcs run in the pressure range of one atmosphere and have local thermal equilibrium in good approximation. The temperatures in these arcs are, in most cases, limited to values below 20,000°K because of the increasing losses by heat conduction with increasing temperatures. Aspects and calculations relating to the energy balance of arcs and a method of reducing the heat conductivity are discussed. Experiments to obtain temperatures in the range above 100,000°K are described and a comparison with theory is given. (W.D.M.)

**807** PLASMA BURNER. Hess, Guenther (to Siemens-Schuckertwerke Aktiengesellschaft). German Patent 1,225,311. Sept. 22, 1966. Filed Apr. 12, 1965.

The plasma burner comprises two coaxially arranged electrodes such that an annular gap exists between them, and magnetic coils provided on the housing of the discharge volume for producing in the gap a magnetic field whereby in operation an arc passing in the gap from the inner to the outer ring-shaped electrode is caused to rotate about the axis of the burner. The housing is surrounded by two axially spaced magnetic poles, the adjacent pole tips of which are conically shaped. The outer ring-shaped electrode is situated between the two adjacent pole tips. (Gmelin Inst.)

### *Stability of Plasma*

*Refer also to abstract 796.*

**808** EXACT INVERSION OF DISPERSION RELATIONS. McCune, James E. (Massachusetts Inst. of Tech., Cambridge). Phys. Fluids, 9: 2082-4(Oct. 1966).

A method is proposed for explicitly determining the complex roots of dispersion relations involving transcendental analytic functions. A simple consequence of Cauchy's theorem, the method has application in many fields, including current plasma problems. (auth)

**809** GRAVITATIONAL INSTABILITY OF PLASMA IN A MAGNETIC FIELD, SET PERPENDICULARLY WITH RESPECT TO THE WAVE VECTOR. Nikolaev, Yu. M. Vestn. Moskov. Univ., Ser. III: Fiz. Astron., No. 6, 82-5 (Nov.-Dec. 1965). (In Russian).

In order to study the gravitational instability of an incompressible fluid in a magnetic field, a system consisting of two infinitely long, ideally conducting compressible fluids within the gravitational field of the Earth were examined under the effect of a homogeneous and constant magnetic field applied to them. The ideally conducting plasma was assumed to be nonviscous and a nonconductor of heat, while electrically neutral and possessing an adiabatic index $n = 2$. Both media were assumed to be isentropic. The magnetogasdynamic equation in the gravitational field was determined, arriving ultimately to a Schroedinger-type equation. In the zero approximation, Taylor's well-known formula was obtained. It was found that if the conducting fluid is infinitely long, the small perturbations do not increase the magnetic field density because they do not distort the magnetic lines of force but decrease the potential energy of the plasma in the terrestrial gravitational field, as a result of which the boundary becomes unstable. (TTT)

**810** NONLINEAR THEORY OF PLASMA INSTABILITY IN AN OSCILLATING DISCHARGE. Vaclavik, J. (Inst. of Plasma Physics, Prague). Czech. J. Phys., 16: 821-7(1966).

An analysis is presented of the nonlinear effects caused by plasma instability in an oscillating discharge. An estimate is made of the energy of unstable oscillations and of the coefficient of turbulent diffusion of plasma using equations of the theory of weak turbulence. (auth)

**811** HOSE INSTABILITY OF A BEAM OF CHARGED PARTICLES PENETRATING A PLASMA. Yadavalli, S. V. (Stanford Research Inst., Menlo Park, Calif.). Z. Phys., 196: 255-73(1966).

Employing the phenomenological approach, the dispersion relation for the "hose" instability of a beam of charged particles passing through a plasma was presented. Energy transfer from the beam is considered. Also, the behavior of the hose instability amplitude under various plasma conditions is discussed in detail. (auth)

**812** CONVECTIVE INSTABILITIES DRIVEN BY ELECTROMAGNETIC WAVES. Lindman, E. L. (Univ. of Texas, Austin). 29p. (CONF-651213-15). ORAU. Gmelin, AED-CONF-65-400-36.

From American Physical Society, Winter Meeting in the West, Los Angeles.

A description of destabilizing effects present in a plasma due to the r-f motion of the two species is obtained by expanding the fluid equations and the electromagnetic wave equations in an asymptotic series in $1/\omega_{rf}$. Equations for the hf and lf motion are separated, linearized, and solved for a plasma with a density gradient perpendicular to a magnetic field. An electromagnetic wave propagating in a direction parallel to the density gradient at a frequency near the lower hybrid is considered. A convenient method of description of the interaction between the electromagnetic wave and the unstable density perturbation involving the simultaneous introduction of more than one phase operator is given. It is found that time average $\overline{v}_{rf} \cdot \nabla \underline{v}_{rf}$ terms which contain the effects of gradient forces lead to instability in qualitative agreement with experiments on electrodeless discharges. (auth)

## Shielding

*Refer also to abstract 595.*

**813** (AD-640865) ANGULAR DISTRIBUTIONS AND ENERGY SPECTRA OF ELECTRONS TRANSMITTED THROUGH AND REFLECTED FROM ELEMENTAL FOILS. Shumway, B. W.; Kreger, W. E.; Brown, R. M. (Naval Radiological Defense Lab., San Francisco, Calif.). Sept. 6, 1966. 33p. (USNRDL-TR-1069). CFSTI $2.00 cy, $0.50 mn.

Experimental electron energy spectra at various angles of emergence or reflection from foils of carbon, aluminum, copper, silver, and gold were measured. Thicknesses used ranged from 0.2 to 0.6 of the electron range. In all cases the incident radiation was a broad, monodirectional, monoenergetic electron beam perpendicular to the foil. Beam energies were 0.5, 0.75, 1.0, 1.5, and 1.95 MeV. The spectrometer used an anthracene crystal as the detector. (auth)

**814** (KR-111) MAGNA: A MULTI-SOURCE GAMMA SHIELDING PROGRAMME. Tveten, Ulf (Institutt for Atomenergi, Kjeller (Norway)). June 1966. 72p. Dep. mn.

MAGNA is a gamma computer program written in FORTRAN 3600 for a CDC 3600 computer. It calculates gamma dose rates in chosen points in or around a set of gamma sources and shields. The sources must be point sources or cylindrical sources, but there are no restrictions to position and orientation. The shields may be cylindrical, cylindrical shell, finite rectangular slab, or infinite slab, and there are very liberal rules to the way the components may be placed. The program was developed as a component shield code and is very useful as such. Shadow-shielding and self-shielding effects are included in the computations. (auth)

**815** (SC-R-66-966) ATTENUATION OF A PLANE-WAVE ELECTROMAGNETIC FIELD BY AN IMPERFECTLY CONDUCTING PROLATE SPHEROIDAL SHELL. Taylor, Clayborne D.; Harrison, Charles W. Jr. (Sandia Corp., Albuquerque, N. Mex.). Oct. 1966. Contract AT(29-1)-789. 13p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The shielding ratio, under quasi-static conditions, is de-

termined for an imperfectly conducting prolate spheroidal shell, when the electric field of the incident plane wave is directed parallel to the major axis of the spheroid. General expressions are obtained for the fields within the cavity. It is shown that the shielding ratio of a spheroid having an eccentricity approaching unity is the same as that of the "corresponding" end-capped cylinder. (auth)

**816** SCATTERING OF γ RADIATION OF $^{226}$Ra AND $^{137}$Cs FROM EARTH AND WATER SURFACE. Vasilev, M. B. At. Energ. (USSR), 21: 135-6(Aug. 1966). (In Russian).

Buildup factors for reflection of γ radiation from 0.1-mg radium and 0.1-mg radium-equivalent cesium sources were studied at various elevations over earth and water surfaces. Graphs of buildup factor variations as a function of elevation showed that for the radium and cesium the buildup factor is always higher over water than over earth. It was also found that under identical conditions the buildup factor for $^{137}$Cs is always higher than for $^{226}$Ra. (R.V.J.)

**817** RADIATION SHIELDING OF MANNED MARS VEHICLES. French, Francis W. (Avco Corp., Lowell, Mass.). J. Spacecraft Rockets, 3: 1544-6(Oct. 1966).

Estimates are made of the radiation shielding requirements for manned Mars vehicles on missions of one to three years duration in the relatively near term time period (early 1980's). Radiations considered in the analysis are the solar flare proton event and the galactic cosmic ray components. For the former, the crew is assumed shielded by a minimum-size "storm cellar," whereas for the latter they are assumed shielded only by the vehicle's shell. (auth)

**818** SHIELDING SPECIAL SITUATIONS. Hall, Wm. Cornelius (Chemtree Corp., Central Valley, N. Y.). 19p. (CONF-660926-1). ORAU.

From International Nuclear Industry Fair and Technical Meetings, Basel.

Shielding special situations is a demanding art. Space, weight, electric insulation, heat conductivity, ease of removal are requirements in addition to radiation attenuation. Special shielding situations are those not satisfied by concrete, sheet metal, lead bricks, welded metal, water or graphite. Materials for special shielding include: boral, boron carbide, cadmium, lithium hydride, masonite, polyethylene, titanium hydride, tungsten, depleted uranium and metallic mortars, the latter being dry powders of varied elemental content, which need only addition of water to be formed and set. (auth)

**819** SENSITIVITY OF MANNED PLANETARY SPACECRAFT DESIGN TO RADIATION UNCERTAINTIES. Savin, Raymond C.; Deerwester, Jerry M.; Mascy, Alfred C. (Office of Advanced Research and Tech., Moffett Field, Calif.). 40p. (CONF-660621-24). ORAU. Gmelin, AED-CONF-66-193-22.

From Health Physics Society, 11th Annual Meeting, Houston, Tex.

Radiation shielding requirements can significantly affect the design of spacecraft systems associated with manned planetary exploration. Some effects of on-board and space radiation on shielding requirements for a variety of manned planetary missions are examined. The missions considered include stopover missions to Mercury, Venus, Mars, Ceres, and Ganymede. Both chemical and nuclear propulsion systems (including high thrust and electric) are considered. Results are presented for the effect of mission duration on spacecraft shielding requirements; galactic, reactor, and solar radiation are considered. The sensitivity of shield weight to uncertainties in solar flare frequency, allowable dose, and recovery factor is also examined. (auth)

## Solid-State Physics

*Refer also to abstracts 315, 364, and 606.*

**820** (AD-631278) ATOMIC CASCADE MODELS. Sherman, Charles H.; Gordon, Nan E. (Parke Mathematical Labs., Inc., Carlisle, Mass.). Feb. 1966. Contract AF19(628)-2419. 32p. (AFCRL-66-164). CFSTI $2.00 cy, $0.50 mn.

A model for cascades of atomic displacements was developed which is basically the same as earlier models but more general in its treatment of replacement collisions and energy lost to other lattice atoms when an atom is displaced. Simple analytical expressions were obtained for the average number of displacements produced per primary which are sufficiently accurate considering the uncertainties in the basic assumptions. Various specific cases of the model are illustrated numerically and discussed briefly relative to the possibility of using electron irradiation data to determine some of the parameters in the model. (auth)

**821** (AD-632466) GENERATION OF AN IMPURITY-VACANCY PAIR IN SILICON DURING IRRADIATION. Mayburg, Sumner (Controls for Radiation, Inc., Cambridge, Mass.). Apr. 8, 1966. Contract AF19(628)-5214. 31p. (AFCRL-66-181). CFSTI $2.00 cy, $0.50 mn.

Equations are solved for the buildup of an impurity-vacancy pair in silicon during irradiation assuming vacancy but not interstitial motion. For a given integrated flux, more pairs are shown to be produced at high than at low bombardment temperatures. When silicon interstitial as well as vacancy motion is considered, the steady-state concentration of vacancies trapped at impurities is found to be $rN_1$ $(1 + r)$ where r is the ratio of interstitial jump time to vacancy jump time and $N_1$ is the concentration of impurities. The disappearance of the pairs after the irradiation ceases is determined by the jump time of the Si interstitials. Comparison of this simple first order theory with available experiments emphasizes the need for experiments to determine the state of the Si interstitial in irradiated silicon at room temperature. Either the Si interstitial is immobile at room temperature or it is trapped by substitutional impurity atoms as Watkins suggested from experiments on Al doped samples at 4K. (auth)

**822** (AD-632467) ADVANTAGES OF THERMAL CONDUCTIVITY IN MEASURED RADIATION PRODUCED COMPLEXES IN SILICON. Glassbrenner, Charles J. (Controls for Radiation, Inc., Cambridge, Mass.). Mar. 1966. Contract AF19(628)-5214. 30p. (AFCRL-66-208). CFSTI $2.00 cy, $0.50 mn.

Phonon thermal conductivity theory is explained to show how thermal conductivity measurements can give the number and size of radiation-produced complexes. A low-temperature thermal conductivity apparatus is described which has a special sample holder for radiation experiments. Proposed experiments to study the radiation damage complexes in silicon containing oxygen and/or carbon are discussed. (auth)

**823** (AD-635005) DIELECTRIC RELAXATIONS IN ADDITIVELY COLORED KCl AND KCl:$SrCl_2$ CRYSTALS. Bucci, Cesare (Pennsylvania Univ., Philadelphia. Dept. of Physics). July 1966. Contract Nonr-551(28). 35p. CFSTI $2.00 cy, $0.50 mn.

The dielectric relaxations of additively colored alkali halides were investigated by means of ionic thermocurrent (ITC) and optical absorption measurements. In addition to the ITC bands present in non-colored KCl crystals, several new bands were found when F centers were partially converted to other centers such as F′, M, N, R, Z, Z1, Z2, and Z3, by F-light irradiation at various temperatures. These additional ITC bands were found to be due to the migration of electrons rather than to the orientation of ionic dipoles. In the particular case of the Z2 centers, which can be obtained only in crystals containing metallic divalent impurities, ITC and field-induced dicroism measurements did not provide any evidence for the existence of an electric dipole moment of the Z2 center itself. Quantitative measurements of the impurity-vacancy dipole (I. V.) concentrations in KCl : $SrCl_2$ crystals indicate, in addition, that the growth of the Z2 centers is accompanied by a decrease of the I. V. band. The proportionality constant between the number of Z2 centers created and the number of I. V. dipoles de-

stroyed during the F to Z2 conversion was slightly more than three. These results support a model for the Z2 center having spherical symmetry and suggest that the process of formation of the Z2 centers is closely related to the association of I. V. dipoles into trimers. (auth)

**824** (LA-3537) RESONANT ABSORPTION BY IMPURITY ATOMS NEAR CRYSTAL SURFACES. Rich, Marvin (Los Alamos Scientific Lab., N. Mex.). Mar. 1966. Contract W-7405-eng-36. 72p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Quantities pertaining to the resonant absorption of $\gamma$ rays by a substitutional impurity atom located near the surface of a simple cubic lattice are considered. The lattice model utilizes central and noncentral harmonic nearest neighbor interactions that decouple the motions in the three principal directions. Recoilless fractions, second order Doppler shifts, and phonon decompositions of the impurity motion are presented as functions of impurity mass and coupling and lattice temperature for equal and unequal central and noncentral forces. The surface asymmetry of the recoilless fraction and the "one-phonon spectra" which occurs in the unequal force case, but not for equal compressional and shear forces, are also examined. (auth)

**825** MULTIPLE-SCATTERING TREATMENT OF LOW-ENERGY ELECTRON-DIFFRACTION INTENSITIES. McRae, E. G. (Bell Telephone Labs., Inc., Murray Hill, N. J.). J. Chem. Phys., 45: 3258-76(Nov. 1, 1966).

A theory of intensities in the diffraction of low-energy ($\lesssim$100-eV) electrons by crystals is formulated on the basis of Lax's multiple-scattering equations. The formulation is self-consistent and is thus applicable regardless of the magnitude of the atomic-scattering factor. The qualitative conclusions of the theory are discussed in detail with reference to simplified model crystals. The theory predicts that the reflectivity curves (reflectivity associated with a given beam versus electron energy) should show two types of peaks in addition to the ordinary Bragg peaks: (a) a resonance peak in the specular reflectivity curve; (b) secondary Bragg peaks in all reflectivity curves. The resonance peak is predicted at an energy just below that of the first appearance of a nonspecular beam. It derives from multiple scattering in a single atom layer and is associated with a resonance (zero and phase discontinuity) in the effective field. The secondary Bragg peaks are predicted at energies given by conditions similar in form to the ordinary Bragg condition. They derive from multiple scattering between atom layers and are associated with the interference between four or more plane wave components of the effective field. Both types of peaks are prominent only when the atomic-scattering cross section is large. All qualitative results are illustrated by an exact numerical application to a model crystal of isotropic (s-wave) scatterers. The relationship with existing theories is discussed. It is shown that the conventional modified kinematical approach to low-energy electron diffraction is a limiting case that is approached when inelastic scattering is dominant. It is also shown that when certain assumptions are introduced, the most important being that of neglecting intralayer multiple scattering and the "two-beam" assumption, the theory reduces to the Darwin dynamical theory. (auth)

**826** INFLUENCE OF THE NATURE OF IONIZING PARTICLES ON THE SPECIFIC LUMINESCENCE OF ORGANIC SCINTILLATORS. Voltz, R.; Lopes da Silva, J.; Laustriat, G.; Coche, A. (Centre de Recherches Nucleaires, Strasbourg). J. Chem. Phys., 45: 3306-11 (Nov. 1, 1966).

The relationship between the specific luminescence dS/dx of organic scintillators and characteristic quantities of the ionizing particle is investigated. Considering the existence of the two scintillation components and the effect of $\delta$ rays, it is shown that dS/dx depends on the specific energy loss dE/dx and on the charge number z of the incident particle: For a given differential energy loss, the ion having the greatest charge number gives rise to the highest light output; for a given particle with increasing dE/dx, the specific luminescence goes through a maximum. The theoretical conclusions are in agreement with experimental results obtained using $\alpha$ particles of 1 to 8 MeV, $^3$He ions in the energy range 1 to 3 MeV and protons from 0.3 to 3 MeV. An experimental device is described, which allows a direct measurement of the energy loss $\Delta$E of particles passing through a thin organic scintillator, and of a quantity proportional to the number $\Delta$S of emitted photons. (auth)

**827** INFLUENCE OF ION BOMBARDMENT ON THE CATHODOLUMINESCENCE OF SILICON CARBIDE. Makarov, V. V.; Petrov, N. N. (Kalinin Polytechnic Inst., Leningrad). Soviet Phys.-Solid State (Engl. Transl.), 8: 1272-6(Nov. 1966).

Translated from Fiz. Tverd. Tela, 8: 1602-7(May 1966).

A study was made of the effect of ion bombardment on the cathodoluminescence spectra of SiC single crystals (6H modification). It was found that the bombardment with 2- to 11-keV $K^+$ ions and heating to a temperature of the order of 1000°C increased strongly the intensity and altered greatly the spectral composition of the radiation excited by bombardment with an electron beam. In the range of photon energies 2.64 to 2.45 eV there appeared a system of narrow intense lines and bands (half widths 0.002 to 0.01 eV). Narrow lines appeared also in the regions of 2.86 to 2.69 and 2.52 to 2.2 eV, although ion bombardment was not a necessary condition for their appearance. In these photon energy ranges differences between the cathodoluminescence spectra obtained from opposite sides of a crystal were observed. (auth)

**828** INVESTIGATION OF CATHODOLUMINESCENCE OF CADMIUM SULFIDE. Gerasimenko, N. N.; Loburets, Yu. V.; Polyakov, G. F.; Smirnov, L. S. (Inst. of Semiconductors, Academy of Sciences, Novosibirsk, USSR). Soviet Phys.-Solid State (Engl. Transl.), 8: 1165-8(Nov. 1966).

Translated from Fiz. Tverd. Tela, 8: 1461-6(May 1966).

The cathodoluminescence spectra and kinetics of the recombination in undoped cadmium sulfide single crystals subjected to bombardment with 200- to 400-keV electron pulses were investigated. It was found that the radiation spectrum depended on the dose of electrons having energies higher than the defect-formation threshold. A considerable difference was found between the kinetics of the green (5000 to 5600 Å) and the red (6000 to 10,000 Å) bands of the spectrum. (auth)

**829** RADIATIVE RECOMBINATION IN GALLIUM PHOSPHIDE EXCITED BY ELECTRICAL INJECTION AND BY ELECTRON BEAMS. Angelova, L. A.; Vavilov, V. S.; Yunovich, A. E. (Lomonosov State Univ., Moscow). Soviet Phys.-Solid State (Engl. Transl.), 8: 1277-9(Nov. 1966).

Translated from Fiz. Tverd. Tela, 8: 1608-12(May 1966).

The dependence of recombination radiation spectra of gallium phosphide on excitation level and impurity content of the crystals was investigated. The crystals were excited by injection via a p–n junction and by fast electron bombardment. (auth)

**830** CERTAIN CHARACTERISTICS OF THE GENERATION OF OPTICAL RADIATION IN CdS AS A RESULT OF ELECTRON EXCITATION. Basov, N. G.; Bogdankevich, O. V.; Devyatkov, A. G. (Lebedev Inst. of Physics, Moscow). Soviet Phys.-Solid State (Engl. Transl.), 8: 1221-2(Nov. 1966).

Translated from Fiz. Tverd. Tela, 8: 1536-8(May 1966).

The generation of optical radiation in CdS crystals by fast electron excitation at liquid-nitrogen temperature is discussed. Some directivity characteristics and the efficiency of production of coherent radiation are presented. (auth)

**831** HIGH PRESSURE VESSEL FOR MEASUREMENT OF PRESSURE-INDUCED PHONON ENERGY SHIFTS BY INELASTIC SCATTERING OF NEUTRONS.

Lechner, Ruep (Reaktorzentrum, Seibersdorf, Austria). Rev. Sci. Instrum., 37: 1534-7(Nov. 1966).

A pressure vessel for neutron inelastic scattering experiments at 3000 atm maximum pressure is described. Rather thin walls with good neutron transmission properties are obtained by making the vessel of five cylinders, each of a high-strength aluminum alloy, which are shrunk one upon another. This "compound cylinder" has a total wall thickness of only 13.5 mm for a (cylindrical) sample volume of 30.6-mm diameter and 65-mm length. The whole range $2\pi$ of scattering angles is accessible. Certain relations are given which were used in calculating optimal cylinder dimensions. Experiments with a lead single crystal show a reduction of Bragg peak intensity to 76% if the crystal is mounted in the vessel. A typical measurement at 3000 atm gives an increase of 2% in phonon energy. (auth)

**832** THE DISTRIBUTION OF MAGNETIZATION IN MIXED MAGNETIC SYSTEMS. I. NON-MAGNETIC IMPURITY. Lovesey, S. W. (Oxford Univ.); Marshall, W. Proc. Phys. Soc. (London), 89: 613-23(Nov. 1966).

The effect of a non-magnetic impurity in body-centered and face-centered ferromagnetic and antiferromagnetic lattices, of general spin, was investigated. By considering a Heisenberg model in the molecular field approximation an expression for the moment deviation at any lattice site was obtained. Numerical calculations of the moment at the first neighbors of the impurity are presented. The elastic diffuse scattering of neutrons is discussed and it is shown that the cross section should have an appreciable temperature dependence in a range which is of experimental interest. (auth)

**833** DISTRIBUTION OF MAGNETIZATION IN MIXED MAGNETIC SYSTEMS. II. ANTIFERROMAGNETIC COUPLING ACROSS A NONMAGNETIC IMPURITY AND ASYMPTOTIC MODEL. Lovesey, S. W. (Oxford Univ.). Proc. Phys. Soc. (London), 89: 625-32(Nov. 1966).

In a previous paper a non-magnetic impurity in a ferromagnetic or antiferromagnetic host was considered as a vacancy in a Heisenberg magnet. Such a model corresponds to the simplest description of a non-magnetic impurity. The effect of antiferromagnetic exchange across the vacancy is considered which corresponds to a coupling that may be stimulated by the impurity, for example MnAu. Numerical values of the moment deviation at the first neighbors of the impurity are given and it is shown that the antiferromagnetic coupling does not merely scale up the magnitude of the moment deviations but also redistributes the total defect on the host. An asymptotic model for the moment deviations are neighbors more distant than the first is derived and numerical results given. (auth)

**834** THE INHIBITION OF F-CENTER PRODUCTION IN ALKALI HALIDES CAUSED BY ELECTRON-TRAPPING IMPURITIES. Pooley, D. (Atomic Energy Research Establishment, Harwell, Eng.). Proc. Phys. Soc. (London), 89: 723-33(Nov. 1966).

The rate of production of F centers in alkali metal halides, during the slow stage of coloration by ionizing radiation, is often reduced by electron-trapping impurities. The conditions for, and extent of, this inhibition are calculated on the assumption that F-center production takes place via electron–hole recombination. The inhibition is determined by the dimensionless parameter S, which is given by $S = (\sqrt{2}/\pi r_k^2)(\dot{n}_\gamma n_0/\nu_h n_I^2) \sim (1/60)(\dot{n}_\gamma n_0/\nu_h n_I^2)$; where $\dot{n}_\gamma$ is the irradiation intensity, $n_0$ the concentration of halogen sites, $n_I$ the impurity concentration, $\nu_h$ the jump frequency of $V_k$ centers and $r_h$ is a constant. For $S \gg 1$ there is little inhibition of the F-center production rate, which is linearly independent on $\dot{n}_\gamma$. When $S = \frac{1}{2}$ the rate is reduced by a factor of two. For $S \ll 1$ the rate is much smaller than in the pure crystal, and depends on irradiation intensity, impurity concentration and crystal temperature through the relation, $(dF/dt) = [c\dot{n}_\gamma^{\frac{1}{2}} \exp(+E_h/2kT)/n_I]$, where $E_h$ is the activation energy for motion of the $V_k$ center. These various predictions are shown to be in good agreement with experiment. (auth)

**835** SPECIFIC HEAT OF GADOLINIUM, TERBIUM, DYSPROSIUM, HOLMIUM, AND THULIUM METALS BETWEEN 3 AND 25 DEG K. Lounasmaa, O. V. (Argonne National Lab., Ill.); Sundstroem, Lorna J. Phys. Rev., 150: 399-412(Oct. 14, 1966).

The specific heat of gadolinium, terbium, dysprosium, holmium, and thulium metals has been measured between 3 and 25°K using a germanium resistance thermometer. Anomalies, apparently associated with magnetic transformations in the metals themselves, were found for terbium at 16°K and for holmium at 17.5°K. Low-temperature peaks, probably resulting from impurities, were observed for gadolinium, terbium, and dysprosium. By assuming that the sum of the lattice and electronic specific heats of all these metals is given by the total $C_p$ of nonmagnetic lutetium and by calculating the nuclear contribution from previous work below 4°K, the magnetic specific heat $C_M$ has been determined. For terbium and dysprosium an exponential temperature dependence, $C_M = 36T^{\frac{1}{2}} \exp(-23.5/T)$ and $C_M = 107T^{\frac{1}{2}} \exp(-31/T)$ (T in °K, $C_M$ in mJ/mole °K), respectively, was found. The results are in accord with current theories that take into account the strong basal anisotropy in the magnetic structure of these metals. For gadolinium $C_M = 0.19T^{2.7}$ above 13°K, but the functional form of $C_M$ is much less certain than for terbium and dysprosium. For holmium $C_M = 1.5T^{3.2}$ represents the magnetic specific heat quite well below 8°K. There is theoretical justification for a $T^3$ temperature dependence of $C_M$ for both gadolinium and holmium. The magnetic specific heat of thulium between 4 and 20°K can be given by $C_M = 8.3T^{2.3}$; no theoretical predictions are available for this metal. The observed behavior of $C_M$ for most of these rare earths can be correlated with existing data on magnetization and electrical resistivity. (auth)

**836** DISPLACEMENT SPIKES IN CUBIC METALS. I. α-IRON, COPPER, AND TUNGSTEN. Beeler, J. R. Jr. (General Electric Co., Cincinnati). Phys. Rev., 150: 470-87(Oct. 14, 1966).

The production of an isolated displacement spike by a collision cascade in α iron, tungsten, and copper at 0°K and the annealing of displacement spikes in α iron at temperatures up to 250°C were studied using the computer-experiment (simulation) method. Collision-cascade simulation in the associated body-centered-cubic (bcc) and face-centered-cubic (fcc) arrays of atoms was based on the approximation of assuming a branching sequence of binary collisions. The primary knock-on atom (PKA) displacement efficiency was found to be a decreasing function of PKA energy, in contrast to the constant displacement efficiency given by structureless solid models. This effect was caused predominantly by damage-production interference among different parts of the cascade. Long-range channeling (range ≥ 1000 Å) played a very minor role in the decrease of the PKA displacement efficiency with increasing PKA energy in bcc metals and none at all in copper. Quasi-channeling events were common and greatly influenced the development of a displacement spike along ⟨110⟩ directions in bcc metals. In this regard, the dimensions of a cascade were determined by the ranges of quasichanneled higher order knock-on atoms in the cascade rather than by the PKA range. The preferred directions for long-range self-channeling were also ⟨110⟩. The calculations suggest that in α-iron and tungsten, only those displacement spikes that would contain clusters of ≥ 10 vacancies at an irradiation temperature of 0°K survive thermal annealing at room-temperature irradiation. Specifically, this means that only those spikes produced by PKA with energies above 3 keV in α iron and above 6 keV in tungsten would contribute surviving defects. The density of displacements in a spike produced at 0°K in α iron was saturated at all PKA energies considered (0.5–20 keV). The temperature dependence of the shape and size of the interstitial-vacancy recombination region in α-iron was determined in part. (auth)

**837** ION-NEUTRALIZATION SPECTROSCOPY OF SOLIDS AND SOLID SURFACES. Hagstrum, Homer D.

(Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev., 150: 495-515(Oct. 14, 1966).

A new method of spectroscopy of solids is presented. By means of it, information concerning the state densities in solids is extracted from measured kinetic-energy distributions of electrons ejected from the solid by slow noble-gas ions. The basic electronic process involved is in the radiationless, two-electron, Auger-type transition which neutralizes the ion to its ground state at the atomically clean solid surface and simultaneously excites another electron in the solid. The method starts with measured energy distributions and, making a minimum of assumptions, works its way back to what may be called the transition density function. This function, which specifies the relative probability that an electron at a given band energy will be involved in the neutralization process, depends on state densities in initial and final states of the process, transition probability, final-state interaction, and other factors. The information obtained is of the same general kind as that obtained by soft x-ray spectroscopy and photoelectron spectroscopy. When the surface is atomically clean the transition density involves bulk-state densities and transition probabilities which depend on the surface. For surfaces with monolayers involving foreign atoms, the transition density is modified by the state-density and wave-function changes resulting from the presence of the two-dimensional surface crystal. The method, feasibility, and characteristics of the ion-neutralization spectroscopy are discussed using experimental data for copper and nickel as illustrative examples. Experimental apparatus and operating conditions are discussed only briefly. (auth)

**838** OPTICAL ABSORPTION OF THE $F_2^-$ CENTER IN SODIUM FLUORIDE. Jones, G. D. (Univ. of Canterbury, Christchurch, N. Zeal.). Phys. Rev., 150: 539-40 (Oct. 14, 1966).

The main absorption band of the $F_2^-$ center in sodium fluoride has been measured as 27 300 $cm^{-1}$ and the band compared with that of the same center in lithium fluoride. (auth)

**839** RADIATION-INDUCED EXPANSION AND INCREASE IN REFRACTIVE INDEX OF MAGNESIUM OXIDE; EVIDENCE FOR THE F CENTER. Primak, William; Luthra, Jagdish (Argonne National Lab., Ill.). Phys. Rev., 150: 551-61(Oct. 14, 1966).

Magnesium oxide single-crystal fragments bombarded with $H^+$, $D^+$, and $He^+$ at several energies between 0.14 and 4 MeV were examined polarimetrically. The dilatation was determined from photoelastic measurements (order of magnitude 0.01), and an increase in refractive index (despite a concomitant decrease in density) was inferred from an interference effect noted in the polarimeter. The depth of the radiation-induced dilatation for the 0.14-MeV ions was determined by an etching procedure. The increase in refractive index was confirmed interferometrically for specimens bombarded with 40-MeV $He^+$, and also the dispersion of the change in refractive index was measured for the visible region. Anomalous dispersion caused by a small absorption band in the visible region was found, but most of the refractive index change was associated with a very large band in the ultraviolet. On thermal annealing the refractive-index increase vanished at ~450°C, but the dilatation remained until much higher temperatures were reached. From the refractive-index change and its dispersion, the wavelength of the ultraviolet absorption peak (~0.26 $\mu$) and the associated number of color centers (multiplied by their oscillator strength) were calculated. Thus the absorption was determined despite impurity absorption which prevented its direct observation. From a comparison with the annealing behavior reported by others for the magnetic resonance signal identified as the F center, it is concluded that the optical absorption band is caused by the F center. It is shown that the expansion can be accounted for largely by vacancies which were generated during ion bombardment and which have formed F centers. Thus the magnesium oxide behaves very much like the alkali halides, except that in the case of the alkali halides vacancies may be introduced by ionization and on annealing may vanish with the centers, whereas in the case of magnesium oxide corpuscular radiation is required to produce the vacancies and on annealing may remain even when the color centers have vanished. (auth)

**840** PARAMAGNETIC RESONANCE TRANSMISSION IN GADOLINIUM. Lewis, Richard B.; Alexandrakis, George C.; Carver, Thomas R. (Princeton Univ., N. J.). Phys. Rev. Lett., 17: 854-7(Oct. 17, 1966).

Using a spin transmission or selective transmission resonance method previously applied to conduction-electron paramagnetic resonance, rather unexpected but unique and characteristic resonance lines transmitted through 99.9%-purity gadolinium foil at temperatures above the Curie temperature of 289°K were observed. The experimental arrangement is described. The sample foil was 75$\mu$ thick, and the skin depth at the frequency used in the experiment (9200 MHz) was about 1 $\mu$. (W.D.M.)

**841** OBSERVATION AND SATURATION OF A MULTIPHOTON PROCESS IN $NdCl_3$. Singh, S.; Geusic, J. E. (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev. Lett., 17: 865-8(Oct. 17, 1966).

Intense visible fluorescence (3300 to 9500 Å) and intensity-dependent attenuation at 1.06 $\mu$ in single crystals of $NdCl_3$ using 1.06-$\mu$ radiation from a cw Nd-doped yttrium aluminum garnet (YAlG) laser were observed. The first observation and saturation of a four-photon process with a cw laser are reported. A schematic of the experimental arrangement is shown. It is demonstrated that in $NdCl_3$, multiphoton spectroscopy can be conducted with a cw Nd: YAlG laser of moderate power and that in this material a step-wise four-photon process involving double-photon transients is operative. (W.D.M.)

**842** ANGULAR DEPENDENCE OF CHANNELLING IN GOLD SINGLE CRYSTALS. Schuckert, R. D. (Technische Hochschule, Munich); Lutz, H.; Sizmann, R. Z. Naturforsch., 21a: 1296-9(Aug. 1966).

The penetration profiles of 70 keV krypton-85 ions in gold single crystals were determined for different incident angles between the ion beam and the ⟨110⟩ or ⟨111⟩ crystal axis. Channelling is most pronounced in the 110 direction but it falls off at first steeply, then at angular deviations larger than 10° rather slowly by tilting to ⟨111⟩ or ⟨100⟩. A sharp aperture cannot be defined for the 110 channel; its half width is of the order of 2 . . . 3°. In ⟨111⟩ no directional channel seems to be operative, although the long tail range distribution indicates a steering of the penetrating ions. (auth)

**843** ELECTRON NUCLEAR DOUBLE RESONANCE AT 35000 Mc/s. Cook, R. J. (National Physical Lab., Teddington, Eng.). J. Sci. Instrum., 43: 548-53(Aug. 1966).

An ENDOR spectrometer operating at 35000 Mc/s with an ENDOR frequency transition range of 1 to 500 Mc/s is described. ENDOR transitions were observed at 300, 77, and 4.2°K. Several systems were studied at 77°K; and the type of information that can be obtained from single crystals, which is obscured in the electron spin resonance, is illustrated. Irradiated succinic acid, sodium formate, glycine, and also unirradiated natural type Ib diamond were studied. From these measurements, one can obtain hyperfine, relative sign, and quadrupole information. (auth)

**844** THE THEORY OF NONSTATIONARY PHENOMENA IN NUCLEAR MAGNETIC RESONANCE. Viglin, A. G.; Dovgopol, S. P. (Ural Polytechnic Inst., USSR). Izv. Vyssh. Ucheb. Zaved., Radiofiz., 9: 617-20(1966). (In Russian).

A general solution was obtained for non-stationary phenomena in nuclear magnetic resonances. Parameters for determining the character of the transition processes and various types of transitions were analyzed. (R.V.J.)

**845** RADIATION OF CHARGE MOVING IN RANDOM-NONHOMOGENEOUS ANISOTROPIC MEDIUM. Begiashvili,

G. A.; Monin, Yu. S. (Inst. of Cybernetics, Academy of Sciences, Georgian SSR). Izv. Vyssh. Ucheb. Zaved., Radiofiz., 9: 627-9(1966). (In Russian).

Incoherent radiation of charged particles moving in a random inhomogeneous anisotropic polycrystal with isotropic crystal distribution was reduced to the equivalent problem of radiation in homogeneous media with effective dielectric penetrability. It was found that the radiation appears even before reaching the Cherenkov threshold, and upon approaching the threshold the radiation intensity grows at a logarithmic rate. (R.V.J.)

**846** LOW-TEMPERATURE IRRADIATION OF INDIUM ANTIMONIDE WITH FAST NEUTRONS. Mirianashvili, Sh. M.; Nanobashvili, D. I.; Razmadze, Z. G. (Tbilissi State Univ., USSR). Soobshch. Akad. Nauk Gruz. SSR, 40: 589-95(1965). (In Russian).

Monocrystalline specimens of InSb were irradiated with fast neutrons at 100 to 300°K in a low-temperature horizontal channel of the reactor of the Institute of Physics, Academy of Sciences Georgian SSR, with continuous measurement of electric conductivity of the specimens. It was found that the decrease in the electric conductivity of InSb specimens of the n type at the initial moment of irradiation occurs at a constant rate and is a linear function of the fast neutron flux. As the time of irradiation increases, however, owing to annealing and recombination of defects, the rate of variation in electric conductivity decreases. The minimal value toward which the conductivity of specimens of the n-type following prolonged irradiation tends is not common to all specimens but depends on the initial donor concentration $N_d$, decreasing with decreasing $N_d$. Fast-neutron irradiation causes in equal quantities two types of disorders of the crystalline lattice of the semiconductor: vacancies and interstitial atoms. This complicates the picture of the energy levels of the defects owing to the appearance in the forbidden zone of InSb of levels associated with the first and second ionization potentials of vacancies and intermediate atoms. The concentration of current carriers in specimens of both n and p types was found to sharply decrease on irradiation. This shows that low-temperature irradiation of InSb produces donor and acceptor levels located sufficiently deeply in the forbidden zone so that electric conductivity decreases. The annealing of radiation damage in the temperature range of 100 to 300°K confirms the assumption that acceptor levels are annealed much more intensively than donor levels. (ATD)

**847** STRESS EFFECTS ON 9 572 $cm^{-1}$ LINE IN IRRADIATED MgO. Stettler, John D.; Shatas, R. A.; Tanton, G. A. (Physical Sciences Lab., Redstone Arsenal, Ala.). 11p. (CONF-660327-9). ORAU. Gmelin, AED-CONF-66-050-30.

From American Physical Society Meeting, Durham, N. C.

Single-crystal platelets of MgO were irradiated with $10^{18}$ $n/cm^2$ in the ORNL research reactor at 100°C and subjected to stresses up to 2.2 kbar in an anvil-type uniaxial stress cell. Absorption spectra were taken at 90 ± 5°K as a function of uniaxial stress in the [100], [111], and [110] directions. Data on the 9572 $cm^{-1}$ zero-phonon line and the structure of its associated phonon bands are presented. Results correspond to a nondegenerate transition in a center of rhombic I symmetry with the electric dipole moment along the [110] direction. The stress data are also used to calculate the associated one-phonon absorption in the Debye region. (A.G.W.)

**848** ANNEALING OF FAST NEUTRON DAMAGE IN IMPURITY-CONDUCTING N-TYPE GERMANIUM. Wolf, E. L.; Compton, W. Dale; Depp, S. W. (Univ. of Illinois, Urbana). 12p. (CONF-660306-23). ORAU.

From American Physical Society, Conference on Isobaric Spin, Tallahassee.

Two samples of n-type Ge containing $2.2 \times 10^{17}$ $cm^{-3}$ Sb donors were irradiated to an integrated neutron flux of $\sim 4 \times 10^{16}$ $n/cm^2$. The irradiated samples were annealed at 10°C intervals from 100 to 380°C for 45 min at each temperature. The Hall constant and the resistivity at 0°C and 78°K were measured after each anneal. The major features of the data are the lack of major annealing below 300°C of all quantities except the scattering center concentration, the gradual annealing and then distinct anneal stage of $1/\mu$ at 275°C, and the failure of the carrier concentration to completely anneal. The data are compared with data for $\gamma$-irradiated Ge, and possible interpretations of the results are considered. (A.G.W.)

**849** INTERPRETATION AND APPLICATIONS OF MOESSBAUER FRACTION EXPERIMENTS. Nussbaum, Rudi H. (Portland State Coll., Portland, Oreg.). 25p. (CONF-660113-3). ORAU. Gmelin, AED-CONF-66-058-2.

From Moessbauer Symposium, New York.

The interpretation of the Mössbauer fraction of gamma rays emitted or absorbed by a nucleus bound in a crystal is fundamentally a problem of lattice dynamics, the central part of which is to find the forces acting between the atoms of the crystal. If these forces were known, all the other lattice dynamical properties could be calculated. A discussion of Mössbauer fraction measurements is presented which considers lattice dynamics, Mössbauer f values and characteristic temperatures, interpretation of f(T) measurements for some simple lattice models, comparison of f studies with thermal data, anharmonicities, anisotropies, surface physics, scattering, and relaxation effects. (W.D.M.)

**850** MECHANISMS OF IONIZING RADIATION SURFACE EFFECTS ON TRANSISTORS. Nelson, David L.; Sweet, Richard J. (Bendix Corp., Southfield, Mich). 31p. (CONF-660705-6). ORAU. Gmelin, AED-CONF-66-222-2.

From IEEE Annual Conference, Palo Alto, Calif.

An investigation has been made of the effects of ionizing radiation on transistor $I_{CBO}$ and $h_{FE}$ with measuring conditions and electrical bias during irradiation as variables. Two current components were identified that affect $I_{CBO}$ and $h_{FE}$ at low levels: surface channel current and surface space charge region recombination-generation current. To explain variations in both $h_{FE}$ and $I_{CBO}$ for both n–p–n and p–n–p transistors, a model has been proposed which includes the effects of bias during irradiation. Based on test results and the model, a procedure was devised consisting of an irradiation screening test followed by temperature annealing, which enables selection of transistor types and individual transistors which are least sensitive to ionizing radiation. (auth)

**851** PARAMAGNETIC CENTERS IN NEUTRON IRRADIATED CALCIUM TUNGSTATE SINGLE CRYSTALS. Chu, Keh-chang; Kikuchi, Chihiro (Univ. of Michigan, Ann Arbor). 14p. (CONF-660705-5). ORAU. Gmelin, AED-CONF-66-222-3.

From IEEE Annual Conference, Palo Alto, Calif.

Preliminary results on radiation effects in laser materials are reported and the importance of ESR in obtaining definitive information about radiation is emphasized. Two prominent groups of lines indentified as paramagnetic tungsten associated with calcium and oxygen vacancies respectively are reported. Uniaxial stress experiment provides further support to this assignment. The measured number of oxygen vacancies is found in good agreement with the theoretical treatment of Kinchin and Pease. (M.H.R.)

## Theoretical Physics

*Refer also to abstracts 538, 587, 588, and 591.*

**852** (AD-632417) A NEW DIRAC BISPINOR FORM OF MAXWELL'S EQUATIONS AND ITS ROLE IN A THEORY OF ELEMENTARY INTERACTIONS. Final Report, Pt. 3, October 1, 1964-April 1, 1965. Leiter, Darryl J. (Boston Coll., Chestnut Hill, Mass.). Aug. 23, 1965. Contract AF19(604)-8819. 16p. (AFCRL-65-855(Pt.3)). CFSTI $1.00 cy, $0.50 mn.

Using the relativistic-operational concept of elementary interaction, it is shown that it is possible to write Maxwell's equations in a bi-spinor form similar to that of the bi-spinor Dirac equation. In the context of a theory of elementary interactions, new electromagnetic interactions are introduced in a natural way through the use of the bispinor Maxwell equations in a Lagrangian formalism. In particular a new "spinor torque" interaction occurs in addition to the usual "Lorentz Force" interaction. The physical effects of this new electromagnetic interaction in a theory of elementary interactions are discussed. (auth)

**853** (AD-634257) THE NULL BUNDLE OF AN EINSTEIN-RIEMANN SPACE. III. EXTENSION. Edelen, Dominic G. B. (RAND Corp., Santa Monica, Calif.). June 1966. Contract AF 49(638)-1700. 45p. (RM-4873-PR). CFSTI $2.00 cy, $0.50 mn.

Extensions of the previous results are obtained and they are applied to a larger class of spaces described by the Einstein field equations of general relativity. The result is a system of partial differential equations involving only scalar unknowns and having certain important homogeneity properties. These properties allow a number of new solutions of the field equations that aid in understanding the implications of gravitational fields. (auth)

**854** (JINR-P-2825) O METODE RESHENIYA ZADACHI TREKH TEL S ISPOL'ZOVANIEM FUNKTSII SHTURMA-LIUVILLYA. (On a Method of Solving of Three-Body Problem by Use of Sturm-Liouville Functions). Zakhar'ev, B. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 12p. Dep. mn.

The use of eigenfunctions of Sturm–Liouville as a basis for decomposition of a wave function of a many-body system instead of usual wave functions in the configuration mixing methods of Feschbach and Born–Oppenheimer permits the calculations to be more precise without additional complications. (auth)

**855** (NYO-3164-2, Lect. 2) GRAVITATIONAL RADIATION. Sachs, R. K. (American Mathematical Society, Providence, R. I.). 10p.

Because exact solutions do not show how gravitational radiation is related to its sources they do not produce useful numbers. To get estimates of the amount of radiation emitted by, say, an exploding supernova, approximation methods must be used. One of the oldest approximation methods is to linearize the field equations. Linearized theory and the numerical estimates that it leads to are considered. Asymptotic approximations and slow-motion approximations are briefly discussed. (W.D.M.)

**856** (NYO-3164-2, Lect. 3) CONSERVED QUANTITIES AND CONFORMAL STRUCTURE IN GENERAL RELATIVITY. Penrose, Roger (Texas Univ., Austin). 8p.

**857** (NYO-3164-2, Lect. 13) TAUB-NUT SPACE AS A COUNTEREXAMPLE TO ALMOST ANYTHING. Misner, C. W. ([California Univ., Livermore]). 15p.

Some of the many unusual properties of the Taub-NUT space are listed. One property, i.e., that Taub space allows, besides the metric which satisfies the empty-space Einstein equations, another unequivalent, maximal analytic extension, is discussed in detail. (W.D.M.)

**858** (NYO-3164-2, Lect. 14) CONSERVATION LAWS ARRIVED AT BY INCLUDING THE SURFACE TERMS IN THE LAGRANGIAN INTEGRAL. Gerlach, Ulrich H. (American Mathematical Society, Providence, R. I.). 21p.

A fruitful way of looking at a system is to analyze the Lagrangian pertaining to the system. In this analysis there are two aspects involved; finding the equations of motion and using the symmetries of the Lagrangian to determine divergences from which conserved quantities can be found. The symmetry properties of the Lagrangian are examined along with the behavior of vectors under point transformations. (W.D.M.)

**859** (NYO-3164-2, Lect. 15) DRAGGING OF INERTIAL FRAMES BY ROTATING MASSES. Cohen, Jeffrey M. (Yale Univ., New Haven, Conn.). 4p.

It is concluded that, as the shell mass (m) increases, the rotating shell has an increasing dragging effect upon the inertial frames within it. As $m \to 2r_0$ ($r_0$ the shell radius), the shell rotation completely determines that of the inertial frames within it while the effect of the inertial frames at infinity upon those within the shell goes to zero. (W.D.M.)

**860** (TID-22361(Pt.1)) A COMPILATION OF BETA EXCITED X-RAY SPECTRA. PART I (AND FOREWORD). ($^{147}$Pm, $^{45}$Ca, $^{32}$P). Preuss, Luther E. (Edsel B. Ford Inst. for Medical Research, Detroit, Mich.). Nov. 1966. Contract AT(11-1)-1239. 205p. Dep. mn. CFSTI $2.25 cy, $1.25 mn.

This laboratory has embarked upon the fabrication of a selected number of beta-excited x-ray sources and the compilation of the spectra from these sources. Thirty-one elements are utilized as target materials and eleven beta emitters are contemplated. A certain standardization is carried out in the study. Assay parameters involving detectors, geometry, etc., are held constant and recorded throughout the compilation so that source intercomparison is possible between spectra from variants of a single-source type, as well as between different source types. Part I consists of the cataloging of the above target elements with $^{147}$Pm, $^{45}$Ca, and $^{32}$P. Ensuing parts shall include beta-excited spectra from the balance of the useful pure beta emitters. The following basic source designs are utilized: the apposition source, the mixture source, and the compound beta-excited x-ray source. Each of these has some relation to the practical beta-excited source that may be fabricated. The compilation is intended to provide a convenient and rapid, qualitative as well as quantitative, reference for the worker utilizing the beta-excited phenomena. (auth)

**861** PROOF OF TIME-DILATATION WITH THE HELP OF THE MOESSBAUER EFFECT. Hoenl, H.; Bennewitz, F. (Univ., Freiburg i. B.). Z. Naturforsch., 21a: 867-9 (July 1966). (In German).

A Lorenz-invariant treatment of the second-order Doppler effect in rotational motions is given. The calculation is then performed in a generally covariant manner. Experimental consequences concerning the mechanical stability of clocks are discussed, and attention is drawn to a possible refinement of the rotational experiments. (auth)

# PHYSICS (HIGH ENERGY)

## Particle Interactions and Properties (Experimental)

### *Electromagnetic*

**862** (BNL-10608) MAGNITUDE OF THE $K_L^0 - K_S^0$ MASS DIFFERENCE. Hill, D.; Robinson, D. K.; Sakitt, M. (Brookhaven National Lab., Upton, N. Y.); Canter, J.; Cho, Y.; Engler, A.; Fisk, H. E.; Kraemer, R. W.; Meltzer, C. M. (Carnegie Inst. of Tech., Pittsburgh, Pa.). [nd]. Contract AT(30-2)-Gen-16. 6p. (CONF-660808-19). Dep. mn. CFSTI &1.00 cy, &0.50 mn.

From 13th International Conference on High Energy Physics, Berkeley, Calif.

The magnitude of the mass difference $|\Delta m| = |m_{K_L^0} - m_{K_S^0}|$ was measured by studying the time dependence of strangeness = −1 hyperons produced by neutral K's originating from the reaction: $K^+ + d \rightarrow K^0 + p + p$. At time t = 0, one has a $K^0$ state. Thus, the intensity of hyperons as a function of time is given by the expression: $N(t)\alpha\ [e^{-\lambda_S t} + e^{-\lambda_L t} - 2\cos(\Delta m t)\, e^{-(\lambda_S+\lambda_L/2)t}]$. The momentum of the neutral K's in our experiment is in the range 100–550 MeV/c. The hyperons were produced in the following reactions: $\bar{K}^0 + d \rightarrow \Lambda^0 + \pi^+ + n$, $\rightarrow \Sigma^0 + \pi^+ + n$, $\rightarrow \Lambda^0 + \pi^0 + p$, $\rightarrow \Sigma^0 + \pi^0 + p$, $\rightarrow \Lambda^0 + \pi^+ + \pi^- + p$, and $\rightarrow \Sigma^0 + \pi^+ + \pi^- + p$. Charged Σ events were not included in this analysis since these events are more difficult to detect and analyze. (auth)

**863** (DESY-66/22) PHOTOPRODUCTION OF SINGLE POSITIVE PIONS BETWEEN 1.2 AND 3 Gev. Buschhorn, G.; Carroll, J.; Eandi, R. D.; Heide, P.; Huebner, R.; Kern, W.; Koetz, U.; Schmueser, P.; Skronn, H. J. (Deutsches Elektronen-Synchrotron, Hamburg (West Germany)). Hamburg Univ. (West Germany). II. Institut fuer Experimentalphysik). Sept. 1966. 13p. Dep. mn.

Differential cross sections for the reaction $\gamma + p \rightarrow n + \pi^+$ are presented for incident photon energies between 1.2 and 3 BeV and pion center-of-mass production angles of 15 to 50 degrees. (auth)

**864** COMPTON SCATTERING OF GAMMA-RAYS FROM BOUND ELECTRONS. Ghumman, B. S.; Anand, S.; Sood, B. S. (Punjabi Univ., Patiala, India). Curr. Sci. (India), 35: 540-1(Nov. 5, 1966).

The integrated Compton scattering cross section of $^{60}Co$ gamma rays at 1.17 and 1.33 MeV from K electrons in tungsten was measured, and a value of 0.7 ± 0.4 was obtained. This value shows that the cross section is greater than or at most equal to that from free and stationary electrons. (J.F.P.)

**865** FORMATION OF PROTON-ANTIPROTON PAIRS IN COLLIDING MUON BEAMS. Yakh'yaev, R. Sh. Vestn. Moskov. Univ., Ser. III: Fiz. Astron., No. 6, 49-54(Nov.-Dec. 1965). (In Russian).

Experiments with colliding electron, positron, and muon beams yield information on the electric charge and the magnetic moment of fermions and the applicability of the laws of quantum electrodynamics for very short distances. Therefore, longitudinally polarized proton-antiproton pairs, formed during the collision of polarized muon beams with distributed charges and anomalous magnetic moments, were investigated. The angular and energy distributions of the formation of proton-antiproton pairs were determined, considering the form factors and longitudinally polarized particles at the initial and final states. An expression was derived for correlating the angular and energy dependence of the degree of polarization and of the relative probability of the formation of proton-antiproton pairs. The energy dependence relations indicated that with increasing muon energy the portion of proton-antiproton pairs with identical sign of longitudinal polarization increases also. (TTT)

### *Weak*

**866** (AD–634496) OBSERVATION OF INTERFERENCE BETWEEN POSITIVE-PION NEGATIVE-PION AMPLITUDES FROM K-L DECAY AND COHERENT REGENERATION. Technical Report, June 1964–May 1966. Russ, James S. (Princeton Univ., N. J. Elementary Particles Lab.). May 16, 1966. Contract Nonr-1858(06). 96p. (TR–42). CFSTI $3.00 cy, $0.75 mn.

A spark chamber–magnetic spectrometer search for interference between positive-pion negative-pion decay amplitudes produced in free K-L decay, in apparent violation of CP invariance in the weak interactions, and from coherent regeneration was performed. Using diffuse beryllium regenerators of different mean densities, evidence was found for maximal constructive interference, independent of the K-S–K-L mass difference. Additional data using a solid beryllium regenerator provide good evidence that the magnitude of the mass difference lies in the interval 0.4 < delta < 0.7 in units of h/S. Data were also taken on regeneration in liquid hydrogen and can be understood on the basis of large constructive interference with no anomalous effects. Optical model calculations of the phase of the regeneration scattering amplitude in beryllium indicate it is largely imaginary, so that the dominant contributions to CP violation are expected to come from the mass matrix and/or Delta $I = \frac{3}{2}$ currents. Implications of interference for CP conserving models are discussed. (auth)

**867** (NEVIS–153) SEARCH FOR INTERMEDIATE BOSONS IN PROTON-NUCLEON COLLISIONS. Burns, R.; Hyman, E.; Lederman, L.; Lee, W.; Rettberg, J.; Sunderland, J.; Danby, G. (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). July 1966. Contract AT(30-1)-1932. 40p. (R–555; CU–257). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

An experimental study was made of high energy muons (≳10 BeV/c) emerging from 30-BeV proton-nucleon collisions as a function of emission angle. Pion and kaon contributions were suppressed by reducing the decay path to an absolute minimum. In this way, the relative sensitivity to short-lived muon sources is enhanced considerably. The residual contribution was studied experimentally. Finally, various models are investigated which would give rise to muons with large transverse momentum. The models are applied to intermediate vector boson production in order to study the sensitivity of the search to the presence of these or other massive states which can decay promptly into leptons. (auth)

**868** (NYO-3651-1) $\Sigma^+$ DECAY PARAMETERS. Berley, D. (Brookhaven National Lab., Upton, N. Y.); Herzbach, S.; Kofler, R.; Yamamoto, S. (Massachusetts Univ., Amherst); Heintzelman, W.; Schiff, M.; Thompson, J.; Willis, W. (Yale Univ., New Haven, Conn.). Aug. 31, 1966. Contract AT(30-1)-3651. 18p. (CONF-660808-18). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 13th International Conference on High Energy Physics, Berkeley, Calif.

The decay parameters of $\Sigma^+ \rightarrow n + \pi^+$ were measured. The decay occurs through the p wave channel: $\alpha_+$ is small (+.047 ± .07); the likelihood ratio $(\gamma = -1)/(\gamma = +1)$ is $2 \times 10^4$. No evidence was found for a violation of T invariance; defining $\phi$ by $\beta = \sin\phi$, $\gamma = \cos\phi$, $\phi = 180° \pm 30°$ was determined. (auth)

**869** VALUE OF Re $\xi$ FROM MEASUREMENT OF A TRANSVERSE COMPONENT OF MUON POLARIZATION IN $K_L^0 \rightarrow \pi^- + \mu^+ + \nu$. Auerbach, L. B.; Mann, A. K.; McFarlane, W. K.; Sciulli, F. J. (Univ. of Pennsylvania, Philadelphia). Phys. Rev. Lett., 17: 980-3(Oct. 31, 1966).

The transverse component of meson ($\mu$) polarization from meson ($K_L^0$) decay was measured and is shown as a

function of meson ($\mu$) kinetic energy. From this measurement the real part of the ratio of the form factor in the hadronic current describing the semileptonic decays of mesons (K) can be determined. (J.F.P.)

**870** MEASUREMENT OF $K^+_{\mu 3}$ DECAY PARAMETERS. Callahan, Andrew C. (Univ. of Wisconsin, Madison); Camerini, Ugo; Hantman, Ronald D.; (and others). Contract W-7405-eng-48. Phys. Rev., 150: 1153-64(Oct. 28, 1966). (UCRL-16593).

$K^+$ mesons stopped in $C_3F_8$ in the Lawrence Radiation Laboratory (LRL) 30-inch heavy liquid bubble chamber were used in a study of the properties of the decay mode $K^+ \rightarrow \pi^0 + \mu^+ + \nu$. The properties studied were the $\mu^+$ and $\pi^0$ energy spectra, $\mu^+$ longitudinal polarization, $\mu^+$ total polarization, and $K^+_{\mu 3}/K^+_{e3}$ branching ratio. The data are consistent with the universal V-A theory, with time-reversal invariance, and $\mu$-e universality. Using the usual form-factor phenomenological expression for the strangeness-changing vector current, it was found that Re $\xi = +0.34^{+0.42}_{-0.28}$, Im $\xi = +0.69^{+0.55}_{-1.0}$, $\lambda_+ = 0.00 \pm 0.05$, $f_+(K_{\mu 3})/f_+(K_{e3}) = 1.01 \pm 0.05$. Im $\xi$ should vanish by time-reversal invariance and $f_+(K_{\mu 3})/f_+(K_{e3})$ should be unity if $\mu$-e universality holds. With these assumptions Re $\xi = 0.41^{+0.27}_{-0.22}$. (auth)

## Strong (Baryon-Induced)

**871** (NEVIS-154) ANNIHILATIONS OF ANTIPROTONS AT REST IN HYDROGEN. VI. KAONIC FINAL STATES. Barash, N.; Kirsch, L.; Miller, D.; Tan, T. H. (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). Sept. 1966. Contract AT(30-1)-1932. 27p. (R-561; CU-258). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Experimental results on the annihilation of stopped antiprotons into $K\bar{K} + 3\pi$, $K\bar{K}\eta$, and $K\bar{K}\omega$ are presented. The branching ratios for $\bar{p} + p \rightarrow K_1K_1\eta$ and $\bar{p} + p \rightarrow K_1K_1\omega$ are found to be $(0.25 \pm 0.04) \times 10^{-3}$ and $(1.08 \pm 0.16) \times 10^{-3}$, respectively. From events of the latter reaction the width of the $\omega$ meson is found to be $12.3 \pm 2.0$ MeV. The $E^0$ meson is observed and evidence is seen for the assignment of even charge conjugation and even G parity to this resonance. In addition, events from the reaction $\bar{p} + p \rightarrow K_1K^{\pm}\pi^{\mp}$ were used to measure the mass difference between the charged and neutral $K^*$. It is found that $M_{K^{*0}, \bar{K}^{*0}} - M_{K^{*\pm}} = 6.5 \pm 3.8$ MeV. (auth)

**872** SMALL-ANGLE PROTON-PROTON POLARIZATION AND CROSS SECTION AT 213 Mev. Marshall, J. F.; Brown, C. N.; Lobkowicz, F. (Univ. of Rochester, N. Y.). Contract AT(30-1)-875. Phys. Rev., 150: 1119-22(Oct. 28, 1966). (UR-875-144).

This experiment was a simultaneous measurement of the proton-proton cross section and polarization for the angular range $8.9°-38.7°$ cm at $213 \pm 6$ MeV. An experimental normalization of the cross section of $\pm 1.3\%$ accuracy was obtained. The results agree with the predictions of the latest phase-shift analyses except for $\theta_{cm} \lesssim 15°$. (auth)

**873** DOUBLE SCATTERING IN HIGH-ENERGY ELASTIC COLLISIONS WITH DEUTERONS. Franco, Victor (Univ. of California, Berkeley); Coleman, Ernest. Phys. Rev. Lett., 17: 827-30(Oct. 10, 1966).

It is suggested that the broad shoulder observed in recent measurements of the p-d elastic differential cross section at 2 Bev is a double-scattering effect, and, it is proposed that further measurements be made to test whether double scattering persists at high energies. (auth)

**874** ISOBAR PRODUCTION IN $p + p \rightarrow p + p + \pi^+ + \pi^-$ AT 6.6 Gev/c. Gellert, Eugene (Univ. of California, Berkeley); Smith, Gerald A.; Wojcicki, Stanley; Colton, Eugene; Schlein, Peter E.; Ticho, Harold K. Phys. Rev. Lett., 17: 884-8(Oct. 17, 1966).

At 6.6 Bev/c, the reaction $p + p \rightarrow p + \pi^+ + p + \pi^-$ proceeds dominantly through the $N^{*++}p\pi$-channel. When peripheral $N^{*++}$'s are selected, the $p\pi^-$ angular distribution reproduces the angular distributions of free $\pi^-p$ scattering in the cms energy range from threshold to 2.0 Bev. The diffraction scattering at the upper end of this energy band can account for the 1.4-Bev $N^*$ deduced in recoil-proton spectrum studies. (auth)

## Strong (Meson-Induced)

**875** (AERE-R-5287) WIDE ANGLE PAIRS PRODUCED IN Pi-NUCLEON INTERACTIONS. Dass, Guru Vachan (Atomic Energy Research Establishment, Harwell (England)); Ross, Marc (Rutherford High Energy Lab., Science Research Council, Chilton (England)). Sept. 1966. 12p. Dep. mn. BIS $0.30, HMSO 1s. 9d.

Some observations are reported on a recent experiment on the interaction of high energy pions (about 930 MeV/c) with nucleons, in which some high mass electron-positron pairs were observed with an invariant mass (total energy in the cms frame of the pair) of about 400 to 600 MeV (but none for energies of about 200 to 300 MeV) in addition to very low mass pairs. (B.G.D.)

**876** (JINR-P-2885) ISSLEDOVANIE REAKTSII $\pi^-p \rightarrow \pi^+ + \pi^- + m\pi^0 + n$ AND $\pi^-p \rightarrow 2\pi^+ + 2\pi^- + m\pi^0 + n$ PRI IMPUL'SE $\pi^-$-MEZONOV 4 Gev/c. (Investigation of the $\pi^-p \rightarrow \pi^+ + \pi^- + m\pi^0 + n$ and $\pi^-p \rightarrow 2\pi^+ + 2\pi^- + m\pi^0 + n$. Reactions at 4 Gev/c $\pi^-$-Meson Momentum). Bem, Ya.; Grishin, V. G.; Kistenev, E. P.; Kopylova, D. K.; Kriventsova, A. G.; Muminov, M. M.; Tszyun, Mu; Ryabtsov, V. D.; Trka, Z. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1966. 34p. Dep. mn.

The $\pi^- + p \rightarrow n + \pi^+ + \pi^- + m\pi^0$ and $\pi^- + p \rightarrow n + 2\pi^+ + 2\pi^- + m\pi^0$ interactions at momentum 4 GeV/c were investigated. $\pi^-p$ interactions, involving $\gamma$ quanta, which produced $e^+e^-$ pairs in the effective volume of a propane chamber were recorded. The events, first one with the production of one and two $\pi^0$ mesons ($\sigma(1\pi^0) = 3.8 \pm 0.7$ mb; $\sigma(2\pi^0) = 3.6 \pm 0.3$ mb) were singled out. The first reaction with m = 2 was investigated in detail. It was shown that in the first reaction the production cross sections of $\omega$, $\rho$, and $\eta$ mesons are small ($\sigma \leq 0.2$ mb). Data are obtained indicating the intensive production of the nucleon isobars $N^*(1688)$ and $N^*(2190)$. It is also shown that, on the whole, a $\pi^0$ meson is produced in the second reaction. (auth)

**877** (JINR-P-2898) FAZOVYI ANALIZ UPRUGOGO PION-NUKLONNOGO RASSEYANIYA PRI 310 Mev. (Phase-Shift Analysis of Elastic Pion-Nucleon Scattering at 310 Mev). Vasilevskii, I. M.; Vishnyakov, V. V.; Ivanchenko, I. M.; Lapidus, L. I.; Silin, I. N.; Tyapkin, A. A.; Shchegel'skii, V. A. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1966. 36p. Dep. mn.

The SPDF phase-shift analysis has been carried out on the basis of more accurate data on recoil proton polarization in 300 Mev $\pi^-$-p scattering and of all available data on $\pi$-p interactions at this energy. A number of variants of phase-shift analysis has been performed. Information on inelastic interaction, charge exchange scattering, obtained by Caris and Lind, was taken into account. The predictions of dispersion relations for the forward $\pi$-N scattering were introduced into the phase-shift analysis. It was shown that the set I which is in general similar to Vik-Rugge set II, statistically is most favorable. (auth)

**878** (NEVIS-149) LOW ENERGY $K^-$-p INTERACTION AND INTERPRETATION OF THE 1405 Mev $Y_0^*$ RESONANCE AS A $\bar{K}N$ BOUND STATE. Kim, Jae Kwan (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). May 1966. Contract AT(30-1)-1932. 101p. (CU-255; R-550). Dep. mn. CFSTI $4.00 cy, $0.75 mn.

Thesis.

Experimental cross sections and angular distributions for $K^-$-p elastic, charge exchange, and various absorption processes were obtained in the region of $K^-$ momenta below 280 MeV/c. The angular distributions show that the interaction is consistent with s-wave interaction and that coulomb-nuclear interference is destructive for the $K^-$-p system. From the analysis of the elastic differential cross sections, independent of zero effective range theory, the

values of modulus and phase of this amplitude were obtained for the two laboratory momenta regions from 100 MeV/c to 180 MeV/c and from 180 MeV/c to 260 MeV/c. As a function of $K^-$ momentum, $\Sigma^-/\Sigma^+$ production branching ratios show the presence of cusp at the threshold of charge exchange scattering. All the experimental results were fitted to the Dalitz-Tuan theory of s-wave zero effective range. From the least square analysis, only one set of constant scattering parameters was found to be consistent with the experimental results. The scattering lengths are: $A_0 = (-1.67 \pm 0.04) + i(0.71 \pm 0.04)$ for the isotopic spin-zero channel and $A_1 = (-0.07 \pm 0.06) + i(0.68 \pm 0.03)$ for the isotopic spin-one channel. This set of scattering lengths predicts a $K^-$-p bound state in the isotopic spin-zero channel. The calculated parameters of this bound state are: $E_r = 1410.7 \pm 1.0$ MeV for the mass, and $\Gamma = 36.4 \pm 3.2$ MeV for the width. The agreement between these calculated parameters of the bound state and the experimental parameters of $Y_0^*(1405)$ is sufficiently striking to permit the conclusion that $Y_0^*$ of mass 1405 MeV is to be understood as an s-wave $K^-$-p bound state. This then establishes the spin and parity of the 1405 $Y_0^*$ as $\frac{1}{2}^-$, using the convention of negative kaon parity. (auth)

**879** (NEVIS-155) $\eta$ AND $\eta'$ PRODUCTIONS NEAR THRESHOLDS IN $\pi^-$-p REACTIONS. Hyman, E.; Lee, W.; Peoples, J.; Schiff, J.; Schultz, C.; Stein, S. (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). Sept. 1966. Contract AT(30-1)-1932. 21p. (R-563; CU-259). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

An experiment to study the reaction $\pi^- + p \rightarrow \eta + n$ near threshold was performed preliminary to a forthcoming measurement of charge asymmetry in $\eta$-meson decay. The $\eta$ was identified by the velocity of the associated neutron. Neutrons produced in the forward hemisphere in the center-of-mass system corresponding to the most energetic neutrons in the laboratory were detected. Data were taken at $\pi^-$ momenta between 670 and 805 MeV/c. The four neutron detectors made it possible to detect neutrons at angles of 0 to 21° from the incident pion beam. Differential cross sections for both pion charge exchange and $\eta$ production calculated from the data are presented. A search was made for $\eta'$ at pion momentum of 1.5 BeV/c, and none were observed. The value $\sigma(\pi^-p \rightarrow n\eta') \leq 60$ $\mu$b was obtained. (auth)

**880** POLARIZATION IN PION-PROTON SCATTERING FROM 670 TO 3750 Mev/c. Chamberlain, Owen; Hansroul, Michel J.; Johnson, Claiborne H.; Grannis, Paul D.; Holloway, Leland E.; Valentin, Luc; Robrish, Peter R.; Steiner, Herbert M. (Univ. of California, Berkeley). Phys. Rev. Lett., 17: 975-8(Oct. 31, 1966).

The polarization parameter in meson ($\pi$)-proton scattering was measured for both positive and negative mesons ($\pi$). The measurement consisted of scattering mesons ($\pi$) from polarized target protons and observing the asymmetry in scattered intensity as the spin directions of the target protons were reversed. Experimental results are presented even though their analysis is not completed. (J.F.P.)

**881** PION PRODUCTION IN $\pi^-$-p INTERACTIONS AT ENERGIES 790, 830, AND 870 Mev. Cason, N. M. (Univ. of Notre Dame, Ind.); Derado, I.; Lamsa, J. W.; Kenney, V. P.; Poirier, J. A.; Shephard, W. D.; Vittitoe, C. N.; Stautberg, J. L. Phys. Rev., 150: 1134-40(Oct. 28, 1966).

Single-pion production was studied in the reactions $\pi^-p \rightarrow \pi^-\pi^+n$ and $\pi^-p \rightarrow \pi^-\pi^0p$ at 790, 830, and 870 MeV. A total of 4193 events in these two channels, divided approximately equally between the three energies, were identified. The most interesting feature of the data is the tendency for events to concentrate at high values of $m_{\pi\pi}$ and low values of four-momentum transfer. These effects are discussed in terms of conventional isobar models and a model involving two-pion exchange. Partial cross sections for the reactions studied are reported for each energy. (auth)

**882** $\pi^-p$ INTERACTIONS AT 2.7 Bev/c (FOUR-PRONG EVENTS). Klein, P. R.; Sahni, R. J.; Kovacs, A. Z.; Tautfest, G. W. (Purdue Univ., Lafayette, Ind.). Contract AT(11-1)-1428. Phys. Rev., 150: 1123-33 (Oct. 28, 1966). (COO-1428-17).

A study was made of 8115 four-prongs produced by the interactions of 2.7-BeV/c $\pi^-$ mesons with protons in the Lawrence Radiation Laboratory 72-in. hydrogen bubble chamber. The total four-prong cross section is found to be 5.01 ± 0.12 mb, and the cross sections for each of the final states are: ($\pi^-p\pi^-\pi^+$, 1.83 ± 0.05 mb), ($\pi^-p\pi^-\pi^+\pi^0$, 1.53 ± 0.04 mb), ($\pi^-n\pi^-\pi^+\pi^+$, 0.67 ± 0.02 mb), [$\pi^-p\pi^-\pi^+$ ($m\pi^0$), ($m \geq 2$), 0.44 ± 0.02 mb], and [$\pi^-n\pi^-\pi^+\pi^+$ ($m\pi^0$), ($m \geq 1$), 0.54 ± 0.02 mb]. The final-state $\pi^-p\pi^-\pi^+$ is dominated by the production of $N^{*++}(1238)$ [(42 ± 4)%] and $\rho^0$ [(38 ± 9)%], and the final-state $\pi^-n\pi^-\pi^+\pi^+$ by the production of $N^{*-}(1238)$ [(72 ± 12)%]. The fractions of $\omega$ and $N^{*++}$ (1238) production in the channel $\pi^-p\pi^-\pi^+\pi^0$ are estimated to be (32 ± 4)% and (20 ± 5) %, respectively. Also presented are the effective-mass plots, production angular distributions, and decay angular correlations. (auth)

**883** MEASUREMENT OF THE pp AND pd SCATTERING DIFFERENTIAL CROSS SECTION AT 4.0 Gev USING SEMICONDUCTOR DETECTORS. Akimov, Yu. K.; Zolin, L. G.; Kalinin, A. I.; Nikitin, V. A.; Pantuev, V. S.; Rob, L.; Sviridov, V. A.; Khachaturyan, M. N. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 88-92 (July 1966). (In Russian).

Methodical problems concerning elastic high-energy particle scattering investigations using semiconductor detectors are considered and the results for 4.0 BeV pp and pd scattering cross sections are given for the values of t in the range $4 \times 10^{-3} \leq -t \leq 7 \times 10^{-2}$ (BeV/c)$^2$. (auth)

**884** OBSERVATION OF KAPPA (730 Mev) PRODUCTION IN $\pi^+$p INTERACTIONS AT 3.2 Gev/c. Cason, N. M.; Mikamo, S.; Subramanian, A. (Univ. of Wisconsin, Madison). Phys. Rev. Lett., 17: 838-40(Oct. 10, 1966).

A narrow peak in the K$\pi$ effective-mass spectrum corresponding to the so-called kappa meson was observed in the reaction $\pi^+ + p \rightarrow \Lambda^0 + K^{+,0} + \pi^+ + \pi^{0,+}$ at 3.2 Bev/c. It is shown that this peak cannot be explained by triangular or box singularity effects. (auth)

**885** PRODUCTION AND DECAY OF $Y_1^*(1760)$ IN THE REACTION $K^- + p \rightarrow K^- + p + \pi^0$. Fenster, S. (Univ. of Chicago); Gelfand, N. M.; Harmsen, D.; Levi Setti, R.; Raymund, M.; Doede, J.; Maenner, W. Contract AF-49(638)-1652. Phys. Rev. Lett., 17: 841-4(Oct. 10, 1966).

Evidence for the reaction chain $K^- + p \rightarrow Y_1^*(1760) \rightarrow Y_0^*(1520) + \pi^0$, $Y_0^*(1520) \rightarrow K^- + p$ is reported. (B.G.D.)

**886** MASS SPECTRUM OF BOSONS FROM 500 TO 2500 Mev IN THE REACTION $\pi^- + p \rightarrow p + X^-$ OBSERVED BY A MISSING-MASS SPECTROMETER. Focacci, M. N.; Kienzle, W.; Levrat, B.; Maglic, B. C.; Martin, M. (CERN, Geneva). Phys. Rev. Lett., 17: 890-3(Oct. 17, 1966).

The combined data on mass spectrum of charged bosons $X^-$ (isospin 1 or 2) produced in the interaction $\pi^- + p \rightarrow p + X^-$ at incident laboratory pion momenta $p_l = 3$ to 12 Bev/c, observed by a missing-mass spectrometer is discussed. (B.G.D.)

# Particle Interactions and Properties (Theoretical)

## General

**887** THIRTY YEARS OF MESONS. Oppenheimer, Robert. Phys. Today, 19: No. 11, 51-8(Nov. 1966).

The history of research on mesons is reviewed. The review includes arguments and predictions for mesons, range of forces with finite mass for the field quanta, the discovery of mesons in cosmic rays, strong interactions and strangeness, and unsolved problems concerning mesons. (J.F.P.)

**888** ENERGY SPECTRA OF A SYSTEM OF INTERACTING RELATIVISTIC PARTICLES. Vologodskii, V. B. Tr. Fiz. Inst., Akad. Nauk SSSR, 29: 139-50(1965). (In Russian).

The energy spectrum of a system consisting of a large number of interacting particles was investigated by applying the quantum field theory to quantum statistics, considering specifically the interaction of a Fermi field with a Bose field. The energy and the extinction of excited elementary systems, determined by delayed Green function poles which represent the analytical extension of thermodynamic Green functions, were taken into account. The cases studied included that of a Bose field, defining pseudoscalar particles and that of the energy spectrum of longitudinal and transversal oscillations, corresponding to Coulomb and delayed interactions, respectively, for examining the electron interactions in an electromagnetic field. Under certain conditions, the same results were obtained for both longitudinal and transversal oscillations. (TTT)

**889** HYDRODYNAMIC THEORY OF MULTIPLE GENERATION TAKING INTO ACCOUNT THE VISCOSITY. Emelyanov, A. A. Tr. Fiz. Inst., Akad. Nauk SSSR, 29: 169-204(1965). (In Russian).

Multiple particle generation from high-energy collisions ($>10^{12}$ ev) is explained in its main outlines by the hydrodynamic theory of Landau. This theory gives the number of particles, the composition of the secondary particles, and the energy and angular distribution. The dispersion of the angular distributions of the secondary particles can be explained by taking into account the viscosity and thermal conductivity of the medium. A method is given for determining the viscosity from the experimental dispersion of the angular distribution. Two cases are treated: that 1) the viscosity does not depend on temperature (T) and that 2) it varies as $T^3$. By taking the viscosity into account it is also possible to explain the double-humped structure in the angular distribution of secondary shower particles. Thus the simple hydrodynamic theory can explain the minimum in the angular distribution, which required a two-center model previously. (TTT)

**890** UP TO DATE CONCEPT IN HYDRODYNAMIC THEORY OF MULTIPLE PARTICLE GENERATION. Feinberg, E. L. Tr. Fiz. Inst., Akad. Nauk SSSR, 29: 155-68(1965). (In Russian).

As developed by Landau, the hydrodynamic theory of multiple particle generation started with a concrete equation of state for a substance, and neglected viscosity and thermal conductivity. The theory generally predicts the composition of the generated particles; it explains the presence of two beams of colliding particles, and correctly describes the average number of particles that are formed. The fireball modification of the theory satisfactorily explains the existence of two bundles or clusters with different energies. However, the theory does not explain a structure with two symmetrical maxima. It does not correctly give the divergence angle of the two clusters or the correct number of secondary particles. Milekhin modified the hydrodynamic theory to predict correctly the breakdown of the fireballs, but his theory gives a minimum rather than a maximum of particles at $\theta = \pi/2$. If the constant $C^2$ itself depends on the temperature, this change in the equation of state possibly could lead to a satisfactory explanation of a maximum, but this suggestion of Milekhin remains undeveloped. The viscosity and temperature increase with temperature, and the theory can be improved by taking these effects into account. However, there is still no satisfactory explanation of a minimum at $\theta = \pi/2$ (36 references). (TTT)

**891** ON THE POSSIBILITY OF TAKING INTO ACCOUNT THREE-PARTICLE FORCES IN THE RELATIVISTIC PROBLEM OF THREE-BODY SCATTERING. Shelest, V. P. (Joint Inst. for Nuclear Research, Dubna, USSR). Dokl. Akad. Nauk SSSR, 167: 799-802(Apr. 1, 1966). (In Russian).

The equations of L. D. Faddeev are suitable for studying the nonrelativistic three-body scattering. A method of obtaining the amplitude matrix elements of three-particle processes can also be found in the relativistic case by suitable adaptation. Bound states and scattering states are considered in the two-particle system. Two sets of equations are derived. One set relates the scattering amplitudes in the bound state and the scattering amplitudes of three unbound particles with the formation of two-particle bound states. The other set of equations relates the scattering amplitudes in the bound state with its decay. These equations deal with pair interaction. The case of three-particle forces is then derived. (TTT)

## *Electromagnetic*

*Refer also to abstract 927.*

**892** (AD-635483) INTERPRETATION OF THE N* EFFECT IN DEUTERON COMPTON SCATTERING. Month, Melvin (Illinois Univ., Urbana. Dept. of Physics). 1966. Contract Nonr-1834(05). 21p. CFSTI $1.00 cy, $0.50 mn.

Calculations of deuteron Compton scattering based on impulse methods demonstrate a peaking of the energy distributions due to the N* pole in the factored nucleon amplitude. It is suggested that the factorization procedure is questionable when a pole exists in the factored amplitude, as is evidenced, for example, by the failure of the impulse technique near threshold where the nucleon pole term is of importance. This difficulty is obviated by correctly treating the N* as an intermediate state. An expression for the deuteron Compton differential cross section was derived. To avoid ambiguities inherent in the spin case, scalar particles were used. A comparison with the limited experimental data available above the photopion threshold produced very encouraging results. (auth)

**893** (JINR-E-2865) DISPERSION SUM RULES AND THE CABIBBO-RADICATI RELATION. Faustov, R. N.; Kallosh, R. E.; Pisarenko, V. G. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 8p. Dep. mn.

It is shown that the sum rules for electroproduction and the Cabibbo-Radicati relation can be obtained from a certain assumption about the high-energy behavior of the virtual isovector amplitude of the Compton scattering on the proton without recourse of current algebras. (auth)

**894** (JINR-P-2891) UPRUGOE e-d RASSEYANIE I NARUSHENIE CP-INVARIANTNOSTI. II. (Elastic e-d Scattering and CP-Invariance Violation. II.). Dubovik, V. M.; Likhtman, E. P.; Cheshkov, A. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 10p. Dep. mn.

Possibilities are discussed in detail of checking the CP violation in electromagnetic interactions of hadrons by using the correlation effects in elastic e-d scattering. It is shown in the one-photon approximation that, when the CP invariance is violated in scattering of electrons by a target polarized normally to the scattering plane, the angular asymmetry of recoil deuterons may be of about 10% at $q^2 = 12F^{-2}$ and $\theta_d = 20°$. The contribution of the CP-invariant asymmetry is neglected. (auth)

**895** (NP-16279) ELEKTROMAGNITNYE FORM-FAKTORY PEREKHODA I NEUPRUGOE RASSEYANIE ELEKTRONOV NA ADRONAKH. (Electromagnetic Form-factors of Transition and Inelastic Scattering of Electrons by Hadrons). Report No. 419. Kondratyuk, L. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Teoreticheskoi i Eksperimental'noi Fiziki). 1966. 16p. Dep. mn.

The cross section and the density matrix for the inelastic scattering of the electron by a hadron with arbitrary spin in the one photon exchange approximation are determined in terms of electromagnetic form factors. The T-noninvariant effects and the angular distribution of the final hadrons in the process $e + N \rightarrow e' + N^* \rightarrow e' + N + \pi$ are discussed. (auth)

**896** PHOTOPRODUCTION OF HARMONIC MESONS WHEN INCIDENT PHOTON ENERGY IS LESS THAN THE MESON REST ENERGY. Garg, R. C.; Vachaspati (Univ.

of Allahabad, India). Indian J. Pure Appl. Phys., 4: 329-31(Sept. 1966).

Starting from the classical theory of scattering of mesons by nucleons and of the photoproduction of harmonic mesons, considered in detail earlier [Vachaspati, Nuovo Cim., 29 (1963), 1143], it is shown that mesons can be produced even if the energy of the incident photon is less than the rest energy of the meson. The cross section ($\sigma_2$) for the production of second harmonic mesons is proportional to the intensity of the incident radiation field; $\sigma_2$ is maximum for incident photons of energy 0.8 $\mu c^2$ = 108 Mev, if the meson mass is taken as equal to that of the pion. The value of $\sigma_2$ at this energy is $2.19 \times 10^{-48}$ $I\sigma_0$ cm$^2$, where I is the intensity of the incident radiation field in ergs/cm$^2$ sec, and $\sigma_0$ is the cross section for the production of first harmonic mesons. (auth)

**897** CALCULATION OF THE BRANCHING RATIO $(\eta \to 2\pi + \gamma)/(\eta \to 2\gamma)$. Pasupathy, J.; Marshak, R. E. (Univ. of Rochester, N. Y.). Phys. Rev. Lett., 17: 888-90(Oct. 17, 1966).

Calculation of the branching ratio $(\eta \to 2\pi + \gamma)/(\eta \to 2\gamma)$ by the extension of the current algebra method described by Weinberg (Phys. Rev. Letters 17, 336(1966)) is reported. (B.G.D.)

**898** LOW-ENERGY THEOREM FOR NON-ABELIAN COMPTON EFFECT AND MAGNETIC-MOMENT SUM RULES. Beg, M. A. B. (Rockefeller Univ., New York). Phys. Rev., 150: 1276-80(Oct. 28, 1966).

Low-energy theorems are derived for the scattering of isovector-vector bosons on nucleons, the external boson mass having been continued to zero. The basic technique is that invented by Low to deal with the ordinary or Abelian Compton effect. These theorems are combined with forward-dispersion relations to yield two magnetic-moment sum rules. One of these sum rules is that derived by Cabibbo and Radicati; the other—to the best of the author's knowledge—is new. Neither sum rule admits of even approximate saturation by the (3,3) resonance. (auth)

**899** $\Xi^- - \Xi^0$ MASS DIFFERENCE. Chew, H. (Western Reserve Univ., Cleveland). Phys. Rev., 150: 1249-51 (Oct. 28, 1966).

The method of Dashen is applied to the calculation of the $\Xi^- - \Xi^0$ mass difference. Assuming that the isoscalar electromagnetic form factors of the $\Xi$ are dominated by the $\omega$ and $\varphi$ poles and that the relevant coupling constants satisfy certain SU(3) relations, approximate expressions for the required form factors are obtained by comparison with the Stanford data on nucleons. The mass difference calculated with a crude linear D function has the correct sign, but the magnitude is subject to large uncertainties, owing primarily to the fact that the $\pi\Xi\Xi$ coupling constant is very poorly known. (auth)

**900** SUM RULE IN $\gamma d \to \pi NN_3^*$ REACTIONS. Chand, Ramesh (Wayne State Univ., Detroit). Phys. Rev., 150: 1268(Oct. 28, 1966).

In the $\gamma + d \to \pi + N + N_3^*$ reactions, where $N_3^*$ stands for the 1238-MeV, I = 3/2, J = 3/2 $\pi$N resonance, the use of the isoscalar plus isovector interaction leads to the sum rule. $R(\pi^+ pN_3^{*-}) - 3R(\pi^0 pN_3^{*0}) + 3R(\pi^- pN_3^{*+}) = R(\pi^- nN_3^{*++}) - 3R(\pi^0 nN_3^{*+}) + 3R(\pi^+ nN_3^{*0})$, for the various production rates. (auth)

**901** FREQUENCY SHIFT IN HIGH-INTENSITY COMPTON SCATTERING. von Roos, Oldwig (Astrophysics Research Corp., Los Angeles). Phys. Rev., 150: 1112-18(Oct. 28, 1966).

The question "Is there an intensity-dependent frequency shift in the Compton scattering of free electrons by high-intensity electromagnetic radiation?" is clarified. It is proven that if the electron is free, i.e., well separated from the electromagnetic beam before and after the interaction, no intensity-dependent frequency shift arises. If, on the other hand, the electron has been interacting with the electromagnetic wave train a sufficiently long time before the actual observation of a Compton scattering event, an intensity-dependent frequency shift will in fact be present. (auth)

**902** SUM RULES FOR MAGNETIC MOMENTS FROM COMMUTATION RELATIONS BETWEEN CURRENT DENSITIES. Kawarabayashi, Ken; Suzuki, Mahjko (California Inst. of Tech., Pasadena). Contract AT(11-1)-68. Phys. Rev., 150: 1181-2(Oct. 28, 1966). (CALT-68-81).

It is shown that the magnetic-moment sum rule suggested by Drell and Hearn can be derived from the commutation relations between charge densities. Another exact sum rule for the isovector magnetic moment is also derived in terms of cross sections: $1/4\pi^2\alpha \int_0^\infty \{[2\sigma_T^V(\nu) - \sigma_T^V(\nu)]_P - [2\sigma_T^V(\nu) - \sigma_T^V(\nu)]_A\}\, d\nu = \mu_T^V/2m$, where $\sigma_T^V(\nu)_P[\sigma_T^V(\nu)_A]$ and $\sigma_T^V(\nu)_P[\sigma_T^V(\nu)_A]$ are the total cross sections for the absorption of a circularly polarized isovector photon by a proton polarized with its spin parallel (antiparallel) to the photon spin in the I = 1/2 and I = 3/2 channels, respectively. This sum rule is derived from the commutation relation between space and time components of vector current densities. (auth)

**903** ASYMMETRIC $\mu$-PAIR PHOTOPRODUCTION AND QUANTUM ELECTRODYNAMICS AT SMALL DISTANCES. Parsons, R. G. (Stanford Univ., Calif.). Contract AT(04-3)-400. Phys. Rev., 150: 1165-74(Oct. 28, 1966). (SLAC-PUB-188).

A sensitive test of the theory of quantum electrodynamics as applied to muons is analyzed. The test consists of photoproducing $\mu$-pairs in hydrogen such that the negative muon is produced at small angles with respect to the incident photon and with nearly all of the available energy. The positive muon and the recoil proton are not detected. The cross section is calculated from the Bethe-Heitler amplitude treating proton recoil exactly. The effect of proton structure is analyzed in terms of the two form factors measured by elastic electron-proton scattering. These form factors are approximated by a power series in the invariant squared four-momentum $q^2$ transferred to the nucleus. Radiative corrections appropriate for the experimental resolution are calculated and are shown to reduce the Bethe-Heitler cross section by about 5 percent. The cross section for muon pairs from the decay of known heavy vector resonances is found to be negligible. The flux of negative muons from the decay of a photoproduced $\pi^-$ is calculated and is shown to be a limiting factor in choosing the energy resolution of an experiment. (auth)

**904** SOME IMPLICATIONS OF THE BOOTSTRAP MODEL FOR THE ELECTROMAGNETIC PROPERTIES OF BARYONS. Barton, G.; Dare, D. (Univ. of Sussex, Brighton, Eng.). Phys. Rev., 150: 1220-31(Oct. 28, 1966).

If baryons are baryon-meson bound states, their electromagnetic (EM) mass splittings result from (i) long-range EM forces between their constituents; (ii) EM mass splittings of their constituents; (iii) charge-dependent corrections (short-range) to the strong forces. The model implies many self-consistency conditions, some of which are exploited to estimate the total baryon magnetic moments in terms of the orbital g values of the mesons, and the baryon EM splittings in terms of Coulomb and magnetic energies and of the observed meson EM splittings. The baryons are treated as static, and effects of type (iii) are assumed not to be crucial. Though our assumptions may constitute a poor model of reality, the results of the model follow immediately from its physics, and should be a reliable qualitative guide to the output of correct but more sophisticated calculations based on similar physical ideas. Comparison with experiment shows that it is essential to include strange particles even when considering the nucleons, and that the motion is not essentially relativistic. Agreement is satisfactory for splittings and for the isovector moment, and less so for the isoscalar moments. Some comments are made on alternative approaches to these problems. (auth)

**905** RADIATIVE CORRECTIONS TO $e^+$–$e^-$ SCATTERING MEDIATED BY NEUTRAL VECTOR BOSONS. Karpf, A. D. (Univ., Freiburg i. B.). Z. Phys., 195: 357-64(1966).

Since it is very likely that the contributions (if there are any at all) of weakly interacting neutral vector bosons to ordinary Bhabha scattering can be increased sufficiently with respect to the common photon process, the weak coupling

constant might be measured with great accuracy in these processes. Therefore it is necessary to know the amount of the radiative corrections to this process, which is calculated. (auth)

**906** QUARK STATISTICS AND BARYON FORM FACTORS. Mitra, A. N.; Majumdar, Rabi (Univ. of Delhi). Phys. Rev., 150: 1194-7(Oct. 28, 1966).

Using the Gell-Mann-Zweig triplet model of quarks (Q), it is shown that the orbital structure of the 3Q wave function has a strong influence on the shape of the baryon form factors. In particular, an antisymmetric wave function (A) predicts nodal behavior of the proton charge form factor even at values of $q^2 \sim 20\ F^{-2}$, in complete disagreement with observation. On the other hand, a symmetrical wave function (S) not only leads to a smooth structure for this quantity, but shows a pattern in qualitative agreement with experiment. Such a wide difference in predictions is physically due to the fact that while an S function of L = 0 can be easily formed with the basic clusters (1,1) and (2,1) in S-wave pairs, an A function of L = 0 needs at least unit values of the partial angular momenta associated with the above clusters. The implication of this result is that within the 56 representation $SU_6$, it discriminates against Fermi statistics which requires A-type functions to go with 56, and favors a sort of parastatistics which at least allows S-type functions in 56. The validity of this "selection rule" is strictly within the premises of a single-triplet quark model, and does not rule out other possibilities in the context of more extended quark models. (auth)

## Weak

*Refer also to abstracts 638, 640, 897, and 905.*

**907** (UCR-34P107-35) FADDEEV EQUATIONS FOR THE THREE PION FINAL STATE INTERACTIONS IN $\tau$, $\tau'$ AND $\eta$ DECAYS. Dunn, Wm. A.; Ramachandran, R. (California Univ., Riverside, Dept. of Physics). [1966]. Contract AT(04-1)-Gen-12. 27p. (CONF-660411-61). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From American Physical Society Meeting, Washington, D. C.

The anisotropy in the pion energy spectra for the various three pion decay modes are assumed capable of providing information concerning the $\pi$-$\pi$ interaction parameters. Such determinations have so far yielded values that radically differ from those obtained from the analysis of low energy pion-nucleon elastic scattering as well as production phenomena. The problem is reconsidered in the light of the complete three body scattering amplitude given according to the description of Faddeev. The assumptions made regarding the kernel of the integral equations include: a simple off shell extension of the two body scattering amplitude, separable in the initial and final momenta; a nonrelativistic framework except for the pion kinematics; and an attractive s-wave $\pi$-$\pi$ interaction in the absence of bound states or resonances. Besides the pion scattering length parameters, a momentum cut off exists which, over a wide range of values, has insignificant effect on the shape of the pion energy spectrum. The integral equations are solved numerically and the parameters that best fit the pion spectra for $\tau$, $\tau'$, and $\eta$ decay are obtained. In each case the s-wave scattering length $a_2$ is found to be much larger than $a_0$. This confirms that the inclusion of the three particle effects do not significantly alter the general features of earlier works. (auth)

**908** (UCRL-11647(Rev.)) FORTRAN SUBROUTINE RANGE: CALCULATING THE RANGE-ENERGY RELATION FOR CHARGED PARTICLES IN CHEMICAL ELEMENTS. Trower, W. Peter (Lawrence Radiation Lab., Univ. of California, Berkeley). Sept. 1, 1966. Contract W-7405-eng-48. 29p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

FORTRAN subroutine RANGE calculates the differential energy loss and the range of charged particles, electrons and positrons excepted, with kinetic energies between 1 MeV and 500 BeV in any chemical element. With the results of the element calculations, the energy loss and range can be readily computed for chemical compounds and mixtures. (auth)

**909** MASS OF THE ELECTRON AND MESON $\beta$-DECAY RATES. Shaffer, R. A. (Oak Ridge National Lab., Tenn. Lehigh Univ., Bethlehem, Pa.). Phys. Rev., 150: 1298(Oct. 28, 1966).

Further considerations are presented of the suggestion that, given the form of the weak interactions, the charged leptons have mass values which maximize meson decays. Previously it has been shown that the muon has that mass which maximizes the quantity $\Gamma_{\pi\mu}/Q_{\pi\mu} + \Gamma_{K\mu}/Q_{K\mu}$. Here $\Gamma$ is the decay rate and Q the Q-value for the indicated two-body decay modes. An extension of this idea to the mass of the electron and $\Gamma/Q$ for the $\beta$ decays of pions and kaons is reported. With a universal, V-A, weak interaction and a conserved vector current, the electron has that mass which maximizes $\Gamma/Q$ for the $\beta$ decays $\pi^- \rightarrow \pi^0$ and $K^0 \rightarrow K^+$. (auth)

**910** THEORY OF NONLEPTONIC HYPERON DECAYS. Chiu, Y. T. (Univ. of Chicago); Schechter, J.; Ueda, Y. Phys. Rev., 150: 1201-8(Oct. 28, 1966).

In the generalized Sugawara-Suzuki model of nonleptonic hyperon decays all amplitudes are given in terms of three parameters describing the current-current "spurion." An attempt is made to estimate the value of these parameters by approximately "saturating" the current-current product with $\frac{1}{2}^+$ octet and $\frac{3}{2}^+$ decuplet intermediate states. Fairly good agreement with experiment is found. This seems to show that weak-interaction universality holds for nonleptonic as well as leptonic decays and to indicate that the so-called "octet dominance" arises automatically. (auth)

**911** NOTE CONCERNING APPLICATIONS OF THE HYPOTHESIS OF PARTIALLY-CONSERVED AXIAL-VECTOR CURRENT. Baker, M. (Inst. of Theoretical and Experimental Physics, Moscow). JETP Lett. (USSR) (Engl. Transl.), 4: 157-60(Sept. 15, 1966).

Translated from Zh. Eksp. Teor. Fiz., Pis'ma Redaktsiyu, 4: 231-5(Sept. 15, 1966).

It is pointed out that the operator equation of the partially conserved axial-vector current hypothesis has never been used in previous work on the consequences of the Gell-Mann chiral SU(3) × SU(3) algebra in which the hypotheses that the divergence of the axial-vector current is proportional to the field and that certain amplitudes are slowly varying functions of the meson ($\pi$) four-momentum in the region between 0 and the meson ($\pi$) mass were made. It is shown that if the second hypothesis is valid, then the predictions in the work considered are valid regardless of whether the first hypothesis is valid or not. But if the second hypothesis is invalid then the predictions are likewise invalid, even if the first hypothesis is correct. (J.F.P.)

**912** NON-RENORMALIZATION OF THE AXIAL VECTOR COUPLING CONSTANT. Shimodaira, Haijime (Saitama Univ., Urawa, Japan). Sci. Rep. Saitama Univ., Ser. A, 5: 49-52(1966).

The derivation of the Ward identity under the condition that the fourth component of the conserved axial vector current commutes with the nucleon field except the nucleon current part derived by Mathur et al., (Nuovo Cim. 31: 874 (1964)) is discussed. It is shown that similar arguments, given by Takahashi (Nuovo Cim. 6: 371(1957)) in order to prove the generalized Ward identity in the conserved current theory, can be applied in the conserved axial vector current case and lead to the generalized Ward identity. (J.F.P.)

**913** ONE-MESON PROPAGATOR AT LARGE MOMENTA. Wellner, M. (Syracuse Univ., New York). Phys. Rev., 150: 1318-20(Oct. 28, 1966).

A recently developed approximation method is used to calculate some contributions to the one-meson propagator at space-like momenta. An SU(3)-invariant interaction is assumed. The nonperturbative formula obtained for the propagator as $p^2 \rightarrow -\infty$ allows one to test the idea of imposing a boundary condition, in this limit, for restricting the coupling constants. An experimentally plausible inequality is obtained. (auth)

## Strong (General)

*Refer also to abstracts 906 and 913.*

**914** PARITY OF FERMIONS: TESTS AND AMBIGUITIES. Button-Shafer, Janice (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 150: 1308-12(Oct. 28, 1966). (UCRL-16857(and Add.)).

Parity tests and ambiguities are discussed for fermion interactions. These include decays into spin-$\frac{1}{2}$ and spin-$\frac{3}{2}$ fermions, as well as fermion production from a polarized target. Complete tests for the several-step decay of a high-spin formation resonance are presented. (auth)

**915** SEARCH FOR FRACTIONALLY CHARGED PARTICLES PRODUCED BY COSMIC RAYS. Kasha, H. (Brookhaven National Lab., Upton, N. Y.); Leipuner, L. B.; Adair, R. K. Phys. Rev., 150: 1140-7(Oct. 28, 1966). (BNL-10228).

Measurements were made of the flux of particles with charges of one-third and two-thirds the charge of the electron, which reach sea level from the vertical with relativistic velocities. A set of six scintillation counters with an acceptance of 650 $cm^2$ sr was directed so that the particles passed through the array. The apparatus was in operation for about 3500 hr. Particles with fractional charge were identified through their characteristic energy loss in each of the six counters. The flux of particles with a charge of one-third was determined to be $(2.6^{+0.9}_{-0.7}) \times 10^{-9}$ $cm^{-2}$ $sr^{-1}$ $sec^{-1}$. The flux of particles with a charge of two-thirds was determined to be $(2.1^{+1.1}_{-0.8}) \times 10^{-9}$ $cm^{-2}$ $sr^{-1}$ $sec^{-1}$. The statistical probability that no anomalously charged particles were detected is about 5%. (auth)

**916** SATURATION IN TRIPLET MODELS OF HADRONS. Greenberg, O. W. (Rockefeller Univ., New York); Zwanziger, Daniel. Phys. Rev., 150: 1177-80 (Oct. 28, 1966).

Triplet models of hadrons are studied according to the criterion of saturation, namely, that the lowest-lying baryons contain exactly three triplets. Two main types of saturation are discussed: Pauli saturation, which depends on antisymmetrization of wave functions, and Coulomb saturation, which relies on the scheme of forces among the particles. The quark, quark-plus-singlet-core, two-triplet, three-triplet, and paraquark models are surveyed, and, using the saturation mechanisms discussed in the text, all of the models are made to satisfy the saturation criterion with the sole notable exception of the quark model, which fails. (auth)

## Strong (Baryon No. = 0)

*Refer also to abstract 907.*

**917** (JINR-P-2879) DISPERSIONNYE PRAVILA SUMM DLYA PROTSESSA ANNIGILYATSII. (Dispersion Sum Rules for Annihilation Process). Matveev, V. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 7p. Dep. mn.

The dispersion sum rules are considered for the annihilation process of baryon-antibaryon octets into a pair of meson octets in the framework of the unitary symmetry. Some relations, which connect meson-meson and meson-baryon coupling constants, are obtained. They are in good agreement with experiment. (auth)

**918** POSSIBLE ONE-CHANNEL CASTILLEJO-DALITZ-DYSON POLES IN $\pi N$ AND $\pi\pi$ SCATTERING. Atkinson, D.; Halpern, M. B. (Univ. of California, Berkeley). Phys. Rev., 150: 1377-86(Oct. 28, 1966).

Interchannel coupling as a qualitative guide in dynamical calculations, and as an ingredient in models of $\pi N$ and $\pi\pi$ scattering is explored. The first model is the SU(6)-symmetric static baryon bootstrap of Capps, Belinfante, and Cutkosky. It is found, on the assumption of a successful bootstrap, that the $P_{11}$ and $P_{33}$ $\pi N$ waves each contain a one-channel Castillejo-Dalitz-Dyson (CDD) pole. If these CDD poles survive SU(6) symmetry breaking, a large number of features of these waves can be correlated, for example, the well-established zero in the $P_{11}$ amplitude, and the observed $P_{33}$ high-energy phase shift. Secondly, it is assumed that the observed nonet of $2^+$ particles is the Regge recurrence of a nonet of $0^+$ extinct bound states, and that these latter can be calculated in a dynamical $0^-0^-$ (3-channel) calculation. It is found, in exact SU(3) symmetry, that certain waves contain one-channel CDD poles; for example, the T = J = 0 $\pi\pi$ wave contains one. On the assumption of SU(6), however, every extinct bound state appears to bring down a CDD pole, in which case there would be no observable consequence of the $0^+$ nonet. In these models, an attempt is made to avoid quantitative group theory, emphasizing general principles that may be valid in a larger context. (auth)

**919** SUM RULES AND A SCALAR UNITARY SINGLET. Kamal, A. N. (Univ. of Alberta, Edmonton). Phys. Rev., 150: 1392-7(Oct. 28, 1966).

The sum rules relating the axial-vector coupling constant to $\pi\pi$ and $\pi N$ total cross sections are derived using the commutation relations between the chiral currents $\chi^+(t)$ and $\chi^3(t)$. The sum rules obtained are the same as those obtained by other authors using the commutation relation between $\chi^+(t)$ and $\chi^-(t)$. It is also shown that the assumption of the existence of the $\sigma$ meson as a scalar unitary singlet helps in saturating the $\pi\pi$ and $K\bar{K}$ sum rules. A definite conclusion cannot be arrived at about the existence of $\sigma$ meson from the $\pi\pi$ sum rule, since the sum rule can equally well be saturated by postulating a large low-energy $\pi\pi$ scattering in I = 0 state, but the $K\bar{K}$ sum rule does seem to require the presence of a particle with properties similar to those of the $\sigma$ meson. SU(3) symmetry is assumed in the latter case. (auth)

**920** SINGLE-CHANNEL CALCULATION OF $\pi\pi$ SCATTERING USING THE MANDELSTAM ITERATION. Bali, Naren F. (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 150: 1358-62(Oct. 28, 1966). (UCRL-16775).

The Mandelstam iteration with appropriate cutoff is shown to be a practical technique for the study of strong-interaction dynamics in the framework of the strip approximation. Comparison with known potential (nonrelativistic) scattering problems shows that the method is accurate enough to allow workable numerical calculations. Calculations of single-channel relativistic $\pi\pi$ scattering with an elementary $\rho$ potential are reported. (auth)

**921** PARTICLE MIXING AND $J^P = 2^+$ MESON DECAYS. Rivers, R. J. (International Centre for Theoretical Physics, Trieste, Italy). Phys. Rev., 150: 1256-62 (Oct. 28, 1966).

Particle mixing for meson fields of arbitrary spin is considered in a field-theoretic context. Expressions for the field renormalization constants and mixing parameters are given in terms of the physical masses, assuming Okubo-type octet breaking. Broken-SU(3) coupling constants are evaluated for the $2^+$ meson decays and the predicted partial widths compared with experiment. Satisfactory agreement is found. (auth)

**922** SIMPLE STATISTICAL MODEL FOR MULTIPLE-MESON PRODUCTION. Matsuda, Satoshi (Tokyo Univ.). Phys. Rev., 150: 1197-1200(Oct. 28, 1966).

A simple statistical model is proposed in order to explain the recently analyzed production rates of various kinds of mesons in $\bar{p}$-p annihilations at rest. The model reproduces the experimental results remarkably well. The physical meaning of the model is also discussed. (auth)

**923** POSSIBILITY OF RISING PHASE SHIFTS THROUGH $\pi/2$ FOR T = 0, s-WAVE, $\pi\pi$ SCATTERING. Dilley, J. (Ohio Univ., Athens). Phys. Rev. Lett., 17: 972-3(Oct. 31, 1966).

The possibility of a rising meson ($\pi$)-meson ($\pi$) phase shift which is associated with a broad low-energy enhancement rather than a resonance peak is indicated. A simple model in which the left-hand cut is replaced by two fixed poles having arbitrary residues is considered. If elastic unitarity and nonrelativistic kinematics are assumed, the model is completely solved by the N/D method. (auth)

**924** HIGH-ENERGY CROSS SECTIONS IN A "QUARK-DROPLET" MODEL. Woo, Ching-hung (Univ. of Maryland, College Park). Contract AFOSR-500-64. Phys. Rev., 150: 1372-6(Oct. 28, 1966).

The following experimental information is available about the high-energy scattering of pp (pn), $\bar{p}p$ ($\bar{p}n$), $\pi^{\pm}p$, and $K^{\pm}p$: (a) the total cross sections, (b) the coefficients b and c in the small-angle parametrization of the differential cross section $d\sigma/dt = Ae^{(bt+ct^2)}$, (c) the ratios of elastic to total cross sections, and (d) the qualitative feature of whether or not the diffraction peak shrinks for the different processes. At the highest available energy, the dependence of these characteristics on the energy becomes relatively weak. A study is made of their dependence on the quantum numbers of the particles involved; that is, how these characteristics are interrelated for the different processes. A "quark-droplet" model is introduced for this purpose. In the approximation where the small differences between pn and pp scattering and between $\pi^+p$ and $\pi^-p$ scattering are neglected, a three-parameter model gives a good description of the relative magnitude of the total cross sections and the absolute magnitudes of b. It gives a poorer but still reasonable description of the relative magnitudes of $(\sigma_{el}/\sigma)$, and the absolute magnitudes of c. It is shown how a small energy dependence of the three parameters can lead to an increase or decrease of b with energy for the different processes, and how a further splitting of the three parameters can satisfactorily account for the differences between pn and pp, and between $\pi^+p$ and $\pi^-p$. The difference between this analysis and the Regge-pole analysis is discussed. A few unsettled points requiring further experimental check are summarized at the end. (auth)

## *Strong (Baryon No. = 1)*

*Refer also to abstracts 918, 924, and 928.*

**925** (JINR-P-2872) BARION-BARIONNOE RASSEYANIE VPERED I KOLLINEARNYE SIMMETRII. (Baryon-Baryon Forward Scattering and Collinear Symmetries). Winternitz, P.; Makarov, A. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 7p. Dep. mn.

Relations between total cross sections for scattering from singlet and triplet states following from the collinear $[SU(3) \otimes SU(3)]$ symmetry, are obtained for baryon-baryon scattering. (auth)

**926** REGGE-POLE ANALYSIS OF $\pi p$ CHARGE-EXCHANGE POLARIZATION. Logan, Robert K.; Sertorio, Luigi (Univ. of Illinois, Urbana). Phys. Rev. Lett., 17: 834-7(Oct. 10, 1966).

A recent measurement of the $\pi^-p$ charge-exchange reaction, $\pi^- + p \rightarrow \pi^0 + n$, at 6 Bev and low momentum transfer which showed a nonzero polarization in apparent contradiction to the Regge-pole hypothesis is discussed. It is demonstrated that this polarization may be explained in terms of the interference of the Regge-pole amplitude with the lower lying resonance in the direct channel, s. Predictions of P for various s and the cross channel t are made. (B.G.D.)

**927** STRONG AND ELECTROMAGNETIC VERTICES. Barnes, K. J. (Imperial Coll. of Science and Tech., London). Phys. Rev., 150: 1331-7(Oct. 28, 1966).

It is suggested that the form factors in the helicity decomposition of the effective coupling of a vector meson to baryons are proportional. This result is shown to follow, within the framework of an $SU(6)_W$-invariant theory, from a speculation closely related to this group. By assuming $\rho$-meson dominance of unsubtracted dispersion relations in the helicity decomposition of the isovector nucleon electromagnetic current, reasonable values of the isovector charge and magnetic moment are obtained simultaneously, thus confirming the above suggestion. A discussion is given of the problems arising in this approach concerning analyticity of the form factors and their behavior both asymptotically and at the threshold points $q^2 = 0$ and $4m^2$. (auth)

**928** REGGE-POLE PHENOMENOLOGY AND FORWARD DISPERSION RELATIONS. Restignoli, M.; Sertorio, L.; Toller, M. (Univ., Rome). Phys. Rev., 150: 1389-92(Oct. 28, 1966).

Six sum rules derived from forward dispersion relations are used to improve the analysis of the forward $\pi$-N, K-N, and $\bar{K}$-N scattering amplitudes in terms of Regge poles. A numerical analysis shows that these sum rules are not in disagreement with the available data regarding total cross sections and forward charge-exchange differential cross sections. It is also shown that they are rather effective in improving the accuracy of the determination of the Regge-pole parameters. The position of the second Pomeranchuk pole and the possible existence of a third vacuum singularity are discussed. (auth)

**929** CROSSING RELATIONS AND BORN TERMS FOR THE PROCESSES: $\pi N \rightarrow \pi N$, $\pi N^* \rightarrow \pi N$, AND $\pi N^* \rightarrow \pi N^*$. Brunet, R. C.; Childers, R. W. (Argonne National Lab., Ill.). Phys. Rev., 150: 1260-91(Oct. 28, 1966).

The calculation of Born terms for the three unitarily coupled reactions, $\pi N \rightarrow \pi N$, $\pi N^* \rightarrow \pi N$, and $\pi N^* \rightarrow \pi N^*$, is considered from two viewpoints: (1) the usual method involving perturbation theory and the invariant amplitudes; (2) a more general method based on the crossing relations of Trueman and Wick. The purpose is to facilitate the inclusion of the $\pi N^*$ channel in relativistic multichannel calculations in which Born terms are used, and also to give a method for calculating Born terms that is independent of perturbation theory. Using this method a simple expression is obtained for the $\pi N$-$\pi N$ Born term of total (orbital) angular momentum J(l) corresponding to the exchange of a baryon of arbitrary mass and spin. A few remarks regarding the removal of kinematic singularities are made. (auth)

**930** CONDITIONS ON PION-NUCLEON SCATTERING DERIVED FROM CURRENT COMMUTATION RELATIONS. Fuchs, Norman H. (Univ. of Pennsylvania, Philadelphia). Phys. Rev., 150: 1241-3(Oct. 28, 1966).

Using the assumptions of current commutation relations and of a partially conserved axial-vector current, new relations between pion-nucleon scattering parameters, the axial-vector renormalization constant $g_A$, and the nucleon-isovector charge and magnetic moment are derived. Calculating the nucleon total magnetic moment, a result is obtained which is in good agreement with experiment. (auth)

**931** SUM RULES FOR P-WAVE PION-NUCLEON SCATTERING LENGTHS FROM CURRENT ALGEBRAS. Raman, K. (Syracuse Univ., N. Y.). Phys. Rev. Lett., 17: 983-5(Oct. 31, 1966).

From current commutation relations and the hypothesis of partial conservation of axial-vector current, sum rules are derived relating $\pi N$ P-wave scattering lengths to the S-wave scattering lengths, the nucleon isovector magnetic moment, $g_A$, and $G_{\pi NN}$. (auth)

**932** REGGE POLES AND PHASES OF $\pi$N-SCATTERING AT $T = 3/2$, AND $J = 3/2$. Lo, Pei-ling; Li, Hua-chung. Ssu Chuan Ta Hsueh Hsueh Pao: Tzu Jan Ko Hsueh, No. 4, 489-96(1964). (In Chinese).

A new form of Regge representation for the scattering amplitude obtained by Huri is applied for calculating phase shifts of $\pi$N-scattering at $T = 3/2$ and $J = 3/2$, at low energies. Whereupon it is assumed that in the partial amplitude at low energies there predominates the term connected with $(3/2, 3/2)$-resonance. (JPRS)

## *Strong (Baryon No. ≥ 2)*

*Refer also to abstract 924.*

**933** (LA-3558) A MONTE CARLO SIMULATION OF A PROTON-PROTON SPIN CORRELATION EXPERIMENT. Bryant, H. C.; Jarmie, Nelson (Los Alamos Scientific Lab., N. Mex.). Aug. 2, 1966. Contract W-7405-eng-36. 43p. Dep. mn. CFSTI $2,00 cy, $0,50 mn.

A FORTRAN IV Code is described that simulates in detail the results to be expected from a proton-proton spin correlation measurement for various assumed values for

the correlation coefficient $C_{nn}$. The life history of a successful event is described with explanations of the more important computational algorithms. Multiple scattering, relativistic, and energy cut-off effects are included. Plots of many of the more significant variable distributions and a listing of the code, CNNJ9, are presented. (auth)

**934** NUCLEON-NUCLEON SCATTERING IN THE FRAMEWORK OF $SU_4$ SYMMETRY. Zech, Hans-Juergen (Univ., Hamburg). Z. Phys., 196: 222-39(1966). (In German).

As a consequence of $SU_4$-invariance, spin singlet and spin triplet phase shifts should be equal for nucleon-nucleon scattering at even angular momenta. The usefulness of assuming $SU_4$-symmetry is tested by calculating, with the use of the Hamada-Johnston potential model for nucleon-nucleon interaction considering only the $SU_4$-invariant central part of the potential, the phase shifts in the energy region from 20 to 320 Mev for l = 0, 2, 4 and by computing with the use of the Born series the corrections to these phase shifts arising from the residual parts of the potential. Although the approximate quality of the singlet phase with one of the triplet phases persists for l > 0, the results obtained do not show promise of great usefulness of the hypothesis of $SU_4$-invariance for discussing nucleon-nucleon interactions. (auth)

**935** NEAR-PERIPHERAL p-p SCATTERING FROM SIMPLE ONE-BOSON-EXCHANGE CONTRIBUTIONS. Bryan, R. A.; Arndt, R. A. (Univ. of California, Livermore). Phys. Rev., 150: 1299-1307(Oct. 28, 1966). (UCRL-14297-T(Rev.1)).

The non-S-wave p-p amplitude is fitted over the 0- to 345-MeV range with three pole terms utilized in a simple fashion; the pole terms are equated with the real part of the scattering amplitude. The imaginary part is then specified by elastic unitarity. The pole terms which give the fit are due to vector-meson exchange ($gv^2$ = 2.3, fv/gv = 2.3, mv = 770 MeV), scalar-meson exchange ($g_{S0}^2$ = 1.6, $m_\sigma$ = 390 MeV), and pion exchange ($g_\pi^2$ = 12.3, $m_\pi$ = 135 MeV). The coupling constants and masses were found with an automatic search routine on an IBM 7094 or CDC 3600 computer. For experiment the single-energy phase-shift analyses of Arndt and MacGregor at 25, 50, 95, 142, 210, and 310 MeV were taken. The pole parameters are consistent with other independent experiments to within the accuracy of the model. The scalar meson is postulated, but may be responsible for the T = 0, S-wave $\pi$-$\pi$ correlation observed in the reaction $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ at low energies. (auth)

**936** DIFFRACTION DISSOCIATION AND THE 1.40-Gev $\pi$N PEAK IN p-p COLLISIONS. Resnick, L. (Niels Bohr Inst., Copenhagen). Phys. Rev., 150: 1292-7(Oct. 28, 1966).

The quasidiffraction model of Drell and Hiida is applied in an attempt to understand the 1.40-BeV maximum seen in high-energy, small-angle, inelastic p-p scattering. Reasonable agreement is found in absolute magnitude, and in dependence on the energy and scattering angle, but the correct position and width cannot be fitted quite accurately; several different phenomenological form factors are attempted. It is shown that, at very forward angles, there is a cancellation in dependence on the off-shell pion mass between the pion propagator and a kinematic factor arising from the diffraction scattering. This leads to a suppression of waves with angular momentum $j > \frac{1}{2}$ for the recoiling system, and might be an explanation for the prominence at very small angles of the 1.40-BeV bump relative to the $d_{13}$ and $f_{15}$ isobars. (auth)

**937** INTRODUCTION TO THE N-QUANTUM APPROXIMATION FOR BOUND STATES: THE DEUTERON IN PSEUDOSCALAR-MESON THEORY. Greenberg, O. W. (Univ. of Maryland, College Park. Rockefeller Univ., New York); Genolio, R. J. Phys. Rev., 150: 1070-6 (Oct. 28, 1966).

The N-quantum approximation for bound states in relativistic quantum field theory is described by applying it to the deuteron in pseudoscalar-meson theory. Some properties of the covariant, single-time, N-quantum amplitude which plays the role of the deuteron wave function are given. A manifestly covariant single-time equation for this amplitude is derived. In the weak-binding, nonrelativistic limit, this equation is reduced to a Pauli-Schroedinger equation with the correct reduced mass and the usual second-order perturbation-theory central and tensor potentials. The interpretation of the N-quantum bound-state amplitude in the weak-binding, nonrelativistic limit is discussed. It is pointed out that a higher approximation will lead to a short-range force between nucleons. (auth)

# Particle Invariance Principles and Symmetries

## General

*Refer also to abstract 962.*

**938** (IC-66/97) ON REPRESENTATIONS OF LIE ALGEBRAS WITH UNBOUNDED GENERATORS. I. PHYSICAL CONSEQUENCES AND MATHEMATICAL PROPERTIES OF DOMAINS. Doebner, H. D.; Melsheimer, O. (International Centre for Theoretical Physics, Trieste (Italy)). 1966. 37p. Dep. mn.

In skew-adjoint representations of non-compact Lie algebras unbounded generators necessarily occur. The physical relevance of the domain $\mathcal{D}$ on which the unbounded generators are defined, is discussed by mathematical techniques due to NELSON. It is explicitly shown that the physical content of a representation depends on the domain $\mathcal{D}$. Some mathematical properties of such domains, which are related to group representations, are collected and formulated. Problems of non-relativistic quantum mechanics (integrable and non-integrable ray representations of the Galilei group, uncertainty relations) and questions related to a nontrivial combination of space-time and internal symmetries (partially integrable representations) are treated as examples. Domains from ladder representation are derived and an integrability proof for these representations is given. (auth)

**939** (IC-66/99) DECOMPOSITIONS OF DISCRETE MOST DEGENERATE REPRESENTATIONS OF $SO_0(p,q)$ WITH RESPECT TO REPRESENTATIONS OF $SO_0(p,q-1)$ OR $SO_0(p-1,q)$. Niederle, J. (International Centre for Theoretical Physics, Trieste (Italy)). Aug. 1966. 23p. Dep. mn.

The decomposition of any most degenerate unitary irreducible representation (single-valued of discrete principal series) of an arbitrary noncompact rotation group $SO_0(p,q)$ ($p \geq q > 1$) with respect to the unitary irreducible representations of its maximal noncompact rotation subgroup $SO_0(p,q-1)$ or $SO_0(p-1,q)$ is derived and characteristic features of the decomposition are discussed. (auth)

**940** (IC-66/101) INFINITE-DIMENSIONAL IRREDUCIBLE REPRESENTATIONS OF LIE ALGEBRAS OF COMPACT UNITARY GROUPS. Fischer, J.; Raczka, R. (International Centre for Theoretical Physics, Trieste (Italy)). Sept. 1966. 41p. Dep. mn.

The discrete and continuous series of infinite-dimensional irreducible representations of Lie algebras of compact unitary groups are derived and their properties are discussed. The possible physical applications are pointed out. (auth)

**941** (JINR-P-2874) O PROSTRANSTVAKH PREDSTAVLENII SIMMETRICHESKIKH GRUPP. (Space Representations of Symmetric Groups). Polubarinov, I. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 22p. Dep. mn.

The bases of spaces are constructed in which irreducible representations of symmetric groups $S_3$ and $S_4$ operate. The results obtained are useful for physical applications of both finite and continuous groups. (auth)

**942** (JINR-P-2886) K TEORII UNITARNYKH PREDSTAVLENII GRUPPY SL(2,c). (On the Theory of Unitary Representations of the SL(2,c) Group). Dao Wong Duc; Nguyen Van Hieu (Joint Inst. for Nuclear Research,

Dubna (USSR). Lab. of Theoretical Physics). 1966. 22p. Dep. mn.

On the basis of the homogeneous functions the bases of the unitary representations of the SL(2,c) group are evidently constructed. The matrix elements of the finite transformations are calculated. The most degenerate principal series of representations of the SL(n,c) group is also considered. (auth)

**943** SYMMETRY PREDICTIONS FROM SUM RULES WITHOUT SATURATION. Gilman, Frederick J.; Schnitzer, Howard J. (California Inst. of Tech., Pasadena). Contract AT(11-1)-68. Phys. Rev., 150: 1362-71(Oct. 28, 1966). (CALT-68-75).

The application of sum rules derived from current commutation relations to give SU(6)-like results is developed without the assumption of saturation. A consistency condition is first derived by comparing sum rules, and the sum rules for $1/g_A^2$ and the isovector charge radii are studied, replacing the assumption of saturation with a simple dynamical model for the remaining continuum contribution. This results in several SU(6)-like predictions which contain important correction factors to the results previously derived assuming saturation. The experimental data for the sum rule for $\langle r_N^2 \rangle^V/6$ were also reexamined, and it was found that it converges below 1 BeV like the sum rule for $1/g_A^2$ when account is taken of the contribution to the sum rule of the large resonant $M_{1+}$ and nonresonant $E_{0+}$ multipoles in pion photoproduction, and of the $N^{**}(1520)$. (auth)

**944** CONSERVATION LAWS AND SYMMETRIES. II. Dass, Tulsi (Univ. of Delhi). Phys. Rev., 150: 1251-5(Oct. 28, 1966).

The reciprocal relationship between conservation laws and symmetries is established for those theories wherein the equations of motion are derivable from a variational principle. It is shown, for a general variational problem with arbitrary number of independent and dependent variables, that to every divergenceless vector there corresponds another which differs from it, in general, by terms that vanish when the Euler-Lagrange equations are satisfied and which has the structure obtained by applying Noether's theorem to some symmetry transformation. Thus existence of a continuity equation implies some invariance property of the variational problem (converse of Noether's theorem). The Lagrangian is invariant, in general, up to a divergence. Derivatives of dependent variables of any arbitrary finite order are allowed to appear in the Lagrangian; it is assumed, however, that it does not contain independent variables explicitly. A systematic procedure is formulated to deduce the invariance property associated with a given conservation law and is illustrated by some examples. (auth)

**945** GAUGE PROPERTIES OF THE MINKOWSKI SPACE. Kastrup, H. A. (Princeton Univ., N. J.). Phys. Rev., 150: 1183-93(Oct. 28, 1966).

The dilatations and the 4-parameter special conformal group are interpreted as geometrical gauge transformations of the Minkowski space and new arguments are given as to why the conventional interpretation of the special conformal group as a set of transformations connecting systems with constant relative accelerations cannot be true. The dilatations and the special conformal group are considered to be approximate symmetries in particle physics in the sense that they become "good" groups at very high energies, but are broken for low energies when the rest masses are important. These properties are illustrated in the case of classical point particles by the partially conserved quantities associated with the new symmetries. One of the interesting features is that the transformation by reciprocal radii appears as a new discrete approximate space-time symmetry. This is probably of interest for the problem of P and CP invariance. The geometrical interpretation is analyzed in terms of homogeneous coordinates and the physical significance of these coordinates is discussed. This analysis leads in a straightforward way to the group O(2,4), which is isomorphic to the full 15-parameter conformal group in Minkowski space, including the full Poincaré group. A conformal-invariant generalization of the usual notion of Einstein causality is given and analyzed. The relationship between tensors and spinors of the group O(2,4) and the usual space-time spinors and tensors is discussed, employing results obtained by Dirac. Finally the field equations for electrodynamics and the pseudoscalar coupling are written down in terms of the new spinors and tensors. These equations do not contain a bare-mass term. The masses are considered to be consequences of the interaction. (auth)

**946** FORM FACTORS AT FINITE MOMENTA. Barnes, K. J. (Imperial Coll. of Science and Tech., London); Kazes, E. Phys. Rev. Lett., 17: 978-80(Oct. 31, 1966).

A formal solution to the algebra of moments is given, and it is demonstrated how this solution may be employed in practice by the use of the $p \rightarrow \infty$ technique. The specific case of the vector current with isospin as the internal algebra is considered. (J.F.P.)

**947** ON THE REDUCTION OF THE REGULAR REPRESENTATION OF THE POINCARE GROUP. Rideau, G. (Institut Poincare, Paris). Commun. Math. Phys., 3: 218-27(1966).

The decomposition of the regular representation of the Poincaré group into irreducible representations is given. (auth)

**948** INHOMOGENEOUS COMPLETION OF NON-COMPACT SEMISIMPLE GROUPS WITH THE MAXIMAL COMPACT SUBGROUP AS LITTLE GROUP. Ne'eman, Y. (Tel-Aviv Univ., Ramat Aviv, Israel). Commun. Math. Phys., 3: 181-6(1966).

An Abelian set of generators $T^u$ is adjoined to a semisimple noncompact Lie group, and its metric chosen so as to have a subset of representations with $T^u T_u > 0$. The dimensionality and transformation properties of the $T^u$ sub-algebra under the homogeneous part, such that they make its maximal compact subgroup into the stability group ("little group") for the above representations are studied. The problem is related to the appearance of inhomogeneous noncompact groups in quantum mechanical problems. (auth)

**949** UNITARITY OF THE S MATRIX IN THE DISTURBED SL(6) SYMMETRY. Nguyen Van Hieu (Joint Inst. for Nuclear Research, Dubna, USSR). Dokl. Akad. Nauk SSSR, 167: 792-4(Apr. 1, 1966). (In Russian).

Since the wave equations disturb the SL(6) symmetry even for free particles, there is no basis to require invariance of the S-matrix with respect to the SL(6) group. It is shown that if the disturbance in SL(6) symmetry is taken into account, the S-matrix is unitary. Moreover, the very condition of unitarity is invariant with respect to the SL(6) group, if 36-dimension momenta are present together with the usual 4-momenta. The scattering of a neutral scalar meson (singlet) on a quark is considered as an example. Expressions are given for the invariant volume element, the invariant $\delta$-function, the matrix element of the process, the phase volume which is invariant with respect to the SL(6) group, and the condition of unitarity with a two-particle approximation. (TTT)

## *Applications (Electromagnetic and Weak)*

*Refer also to abstracts 894 and 954.*

**950** PHENOMENOLOGICAL ANALYSIS OF CP NONINVARIANCE IN $K^{\pm} \rightarrow 3\pi$ DECAY. Barrett, Barbara (San Francisco State Coll.); Truong, Tran N. Phys. Rev. Lett., 17: 880-4(Oct. 17, 1966).

An attempt is made to analyze the effect of CP noninvariance in the decay $K^{\pm} \rightarrow 3\pi$ under the assumption that the violation of CP invariance, first observed by Christenson et al. (Phys. Rev. Letters 13, 138(1964)), occurs in the weak interactions. (B.G.D.)

**951** WEAK-INTERACTION PREDICTIONS OF R(11). Joseph, D. W.; Smalley, L. L. (Univ. of Nebraska, Lincoln). Phys. Rev., 150: 1209-17(Oct. 28, 1966).

Further consideration is given to R(11) as a possible alternative to SU(6); in particular, predictions concerning weak-interaction currents are investigated. Because of indeterminacy in the definition of the physical baryons, a further condition is needed to obtain a significant prediction; time-reversal invariance furnishes such a condition. The prediction $3f^2 + d^2 = 9/8$ then results for the parameters describing the axial-vector octet. Combination of this result with the experimental value of $\mu_p/\mu_n$ yields $(G_A/G_V)_{n\to p} = 1.17$, in complete agreement with the experimental value $1.18 \pm 0.02$. (auth)

### *Application (Strong)*

*Refer also to abstracts 917, 925, and 934.*

**952** NEW METHOD FOR ASSIGNING BARYON RESONANCES TO SU(3) MULTIPLETS. Kernan, Anne; Smart, Wesley M. (Univ. of California, Berkeley). Phys. Rev. Lett., 17: 832-4(Oct. 10, 1966).

SU(3) assignments for baryon resonances can be inferred from the relative phases of the resonant amplitudes in two-body inelastic channels. An application is made to $Y_1^*$ resonances in the channel $K^- + n \to \Lambda + \pi^-$. (auth)

**953** GENERALIZED NONET REPRESENTATION OF SU(3) x SU(3) AND ITS APPLICATIONS. Bose, S. K. (International Centre for Theoretical Physics, Trieste, Italy). Phys. Rev., 150: 1231-5(Oct. 28, 1966).

A class of representations of the nonchiral SU(3) ⊗ SU(3) is worked out. These consist of a sequence of self-conjugate representations of SU(3), starting always with a singlet and with each SU(3) representation occurring once. An analog of the Gell-Mann–Okubo mass formula, valid for these representations of SU(3) ⊗ SU(3), is obtained. When applied to the lowest nontrivial representation, this formula correctly explains $\omega$-$\phi$ mixing, thus providing a justification of Okubo's ansatz. Possible use of the next higher representation is indicated. From the same construction, the corresponding unitary irreducible representations of SL(3,C) and $T_8 \times$ SU(3) are simultaneously obtained. (auth)

**954** TIME-REVERSAL INVARIANCE IN S-MATRIX THEORY OF STRONG AND ELECTROMAGNETIC INTERACTIONS OF HADRONS. Frazer, William R. (Univ. of California, San Diego, La Jolla). Phys. Rev., 150: 1244-8(Oct. 28, 1966). (UCSD–10P10-2).

The formulation of analytic S-matrix theory was examined in the absence of time-reversal invariance. As anticipated, no difficulties were encountered in setting up the necessary formalism: $ND^{-1}$ method, definition of coupling constants, etc. Some successful S-matrix calculations were reexamined without the assumption of T invariance. In all of these, T invariance emerged as a consequence of the dynamics. Photoproduction of the N*(1238) provides the most interesting example, since T invariance emerges as a consequence of a bootstrap principle. The predicted T invariance implies that several proposed tests for T violation involving the $N^*(1238)N\gamma$ vertex should yield negative results to the extent that the S-matrix theory of this vertex is successful. (auth)

**955** $SU(6)_W$ AND TENSOR FORCES. Capps, Richard H. (Northwestern Univ., Evanston, Ill.). Phys. Rev., 150: 1263-7(Oct. 28, 1966).

The one-meson exchange potentials in MB, MM, BB, and $B\bar{B}$ states may be represented approximately by sums of central and tensor potentials, where M and B denote the meson and baryon supermultiplets of dimensions 36 and 56. This formulation leads to a clarification and generalization of a model developed recently, in which the relative forces in different channels are assumed equal to the relative magnitudes of the Born-approximation scattering amplitudes at the physical threshold. It is shown that the tensor forces dominate the $SU(6)_W$-symmetric meson bootstrap model, in which the M are MM bound states. A generalization of a theorem proved previously implies that the tensor forces cancel in the MM, MB, and $B\bar{B}$ states corresponding to the larger SU(3) representations, and in all BB states. Actual nucleon-nucleon forces are very sensitive to symmetry breaking; the implications of the theorem for these forces are discussed and compared with phenomenological analyses of experiment. (auth)

**956** W-SPIN SELECTION RULES. Horn, D. (Argonne National Lab., Ill.). Phys. Rev., 150: 1218-19 (Oct. 28, 1966).

The relation between the additive quantum numbers of the W-spin operators and the multiplicative quantum numbers of reflection in a plane is discussed. Two types of W-spin selection rules are found: those that are identical to the selection rules that come from the general principle of reflection invariance, and those that form new additional restrictions. The implications of the latter group for the baryons and mesons are discussed. (auth)

**957** PARTIAL CURRENT CONSERVATION AND A PHENOMENOLOGICAL MODEL OF HADRONS. Welling, Daniel J. (Argonne National Lab., Ill.). Phys. Rev., 150: 1398-1405(Oct. 28, 1966).

A method for constructing a phenomenological Lagrangian of the hadrons within the relativistic SU(6) framework is presented. The method consists of imposing on the Lagrangian the condition (PCAC) that the divergence of the axial-vector current should be proportional to a nonet of pseudoscalar mesons. A particular SL(6,C)-invariant series of meson-meson and meson-baryon interactions are introduced and it is shown that in a first-order calculation a relation between the various couplings is possible if PCAC is maintained. It is assumed that the model is a phenomenological one, so the interactions consist of fields associated with the physical particles and therefore relations among the couplings can be computed. The effective couplings for all meson-meson and meson-baryon interactions admitted by this model are then obtained to lowest order using one experimental value. If the coupling constant for $\rho\pi\pi$ is used as the sole input, particularly the following results are noted: (a) For the quadrilinear meson process $X^0 \to \eta\pi\pi$, $\Gamma(X^0 \to \eta\pi\pi) =$ 2 MeV. (b) For the decay $\omega \to 3\pi$, $\Gamma(\omega \to 3\pi) = 8.9$ MeV. (c) The $\bar{N}N\rho$ coupling is determined consistent with universality to be $g^2_{\bar{N}N\rho}/4\pi = 0.54$. (auth)

**958** UNITARY IRREDUCIBLE REPRESENTATIONS OF SU(2,2). Kihlberg, A. (CERN, Geneva); Mueller, V. F.; Halbwachs, F. Commun. Math. Phys., 3: 194-217(1966).

Using a Lie algebra method based on works by Harish-Chandra, several series of unitary, irreducible representations of the group SU(2,2) are obtained. (auth)

## Quantum Field Theories

*Refer also to abstract 971.*

**959** (JINR–P-2856) INFRAKRASNYE OSOBENNOSTI FUNKTSII GRINA V PROIZVOL'NOI KALIBROVKE. (Infrared Singularities of the Green Function in the Arbitrary Gage). Zhuravlev, V. I.; Solov'ev, L. D. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 5p. Dep. mn.

In the infrared region all singularities are found of the Green function of a charged particle in all orders in e and in arbitrary gauge. (auth)

**960** (JINR–P-2870) NELOKAL'NAYA KVANTOVAYA TEORIYA SKALYARNOGO POLYA. (Nonlocal Quantum Theory of Scalar Field). Efimov, G. V. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 22p. Dep. mn.

A scheme is suggested for constructing the S-matrix using the perturbation theory free from ultraviolet divergences by the example of the one-component scalar quantized field. The S-matrix is unitary on the mass shell. The causality is violated in small space-time regions. The effects, which are due to this violation at

large distances, are described by very high perturbation orders, and therefore are very weak in perturbation theory. (auth)

**961** A REMARK ON THE ANALYTICITY OF QUANTUM ELECTRODYNAMICS IN $\alpha$. Kotsakis, B.; Pfister, H. (Univ., Munich). Z. Phys., 195: 354-6(1966).

It is shown that Dyson's construction of the fictitious world (e.g., quantum electrodynamics II in contrast to normal quantum electrodynamics I) (Phys. Rev., 85: 631 (1952)) cannot give any argument against or in favor of the analyticity of quantum electrodynamics in $\alpha$, i.e., the convergence or divergence of perturbation series. For this purpose the consequences of the attraction of like charges are studied in more detail than was done previously. (J.F.P.)

**962** CHARGES AS INTEGRALS OF DENSITIES. Swieca, J. A. (Univ. of Sao Paulo, Brazil). Phys. Rev. Lett., 17: 974-5(Oct. 31, 1966).

It is shown that unitary operators giving rise to approximate symmetries associated with nonconserved currents cannot exist in relativistic field theory. (auth)

**963** MAGNETICALLY CHARGED FIELDS WITH INTEGER SPIN. Yan, Tung-mow (Harvard Univ., Cambridge, Mass.). Phys. Rev., 150: 1349-51(Oct. 28, 1966).

Schwinger's field theory of magnetic charge is extended to the case of charged fields with spin 0 or 1. A double limiting process is employed in redefining the energy densities of the charged fields in order to satisfy relativistic invariance. (auth)

**964** GAUGE INVARIANCE, LORENTZ COVARIANCE, AND CURRENT CORRELATION FUNCTIONS. Brown, Lowell S. (Yale Univ., New Haven, Conn.). Phys. Rev., 150: 1338-48(Oct. 28, 1966).

Current correlation functions are defined by means of the response of a system to variations in an external potential. These functions contain, in addition to the time-ordered product of current operators, extra terms that are related to the equal-time noncommutativity of charge and current densities. Although the time-ordered product is not Lorentz-convariant, the requirement of gauge invariance is shown to imply the Lorentz covariance of the entire current correlation function. (auth)

**965** DYNAMICS AT INFINITE MOMENTUM. Weinberg, Steven (Univ. of California, Berkeley). Phys. Rev., 150: 1313-18(Oct. 28, 1966).

Old-fashioned perturbation theory is applied to a relativistic theory in a reference frame with infinite total momentum. It is found that many undesirable diagrams disappear. The contribution of the remaining diagrams is described by a new set of rules with properties intermediate between those of Feynman diagrams and old-fashioned diagrams, e.g., energy denominators become covariant, and Feynman parameters appear naturally. The new rules are used to derive some integral equations. (auth)

**966** N-QUANTUM SOLUTION OF THE DERIVATIVE COUPLING MODEL. Greenberg, O. W. (Univ. of Maryland, College Park. Rockefeller Univ., New York). Phys. Rev., 150: 1076-8(Oct. 28, 1966).

The derivative coupling model is solved using the N-quantum approximation. It follows by inspection of the form of the solution that there is no scattering. Although the Wightman and Green's functions of this model are nontemperate, the N-quantum amplitudes are temperate. The way in which the temperate N-quantum amplitudes lead to nontemperate Wightman and Green's functions is pointed out. It is suggested that the N-quantum approach may be useful in the study of nonrenormalizable field theories. (auth)

**967** INSTABILITY OF STATIONARY STATES OF A NONLINEAR SPINOR FIELD. Rybakov, Yu. P. Vestn. Moskov. Univ., Ser. III: Fiz. Astron., No. 6, 62-7(Nov.-Dec. 1965). (In Russian).

In connection with Heisenberg's studies concerning the identification of all of the elementary particles by means of a single nonlinear equation, the four-spinor system attracted special attention because it is transformed by the simplest irreducible representation of the complete Lorentz group, thus indicating the relative simplicity of the equation. The mathematical analysis carried out indicated that hardly any of the classical nonlinear spinor fields is free from instabilities, as the result of the sign change of the field energy. A theory must be developed to satisfy the Legendre effect, determining the quadratic form of field derivatives; this is not the case for spinor fields described by second-order equations. It may be expected that stable fermions (electron and proton) are obtained through certain boson-type stable fields on the basis of quantum theoretical considerations. It is pointed out that in the description of decay properties of elementary particles, corresponding to weak interactions, a four-fermion interaction, similar to the considered nonlinearity, is used. (TTT)

**968** MODEL OF A NONLINEAR SCALAR FIELD WITH STABLE PARTICLE-LIKE SOLUTIONS. Martsinkevich, I. E. Vestn. Moskov. Univ., Ser. III: Fiz. Astron., No. 6, 24-8(Nov.-Dec. 1965). (In Russian).

Following up studies on simplified models in the nonlinear field theory of elementary particles, a new, simplified model of the nonlinear complex scalar field is proposed. A stationary, spherically symmetric solution of the Lagrangian function describing the model was derived. An examination of the stability of the solution with respect to small perturbations at the initial period revealed that the model satisfies the requirement of stability. Using an additional condition of charge standardization, the mass spectrum was obtained and represented graphically. The stability of the obtained solution with respect to small perturbations was found to satisfy Yu. P. Rybakov's condition. (TTT)

**969** FOCK REPRESENTATION AND MASSLESS PARTICLES. Doplicher, S. (Univ. of Aix, Marseille). Commun. Math. Phys., 3: 228-32(1966).

Some remarks on the representations of canonical commutation or anticommutation relations which describe free massless particles are presented. (auth)

## Scattering Theory

*Refer also to abstracts 891, 949, and 960.*

**970** (JINR-P-2869) OB USLOVII POLNOTY V TEORII POTENTSIAL'NOGO RASSEYANIYA. (On the Completeness Condition in Potential Scattering Theory). Khelashvili, A. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 8p. Dep. mn.

It is shown that the orthogonality of wave functions leads to the unitarity of the physical scattering amplitude. The completeness condition together with the asymptotical behavior of the wave functions is equivalent to the nonrelativistic dispersion relations. (auth)

**971** (JINR-P-2873) DISPERSIONNYE SOOTNOSHENIYA I FUNDAMENTAL'NAYA DLINA V KVANTOVOI TEORII POLYA. (Dispersion Relations and Elementary Length in Quantum Field Theory). Logunov, A. A.; Nguyen Van Hieu (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 11p. Dep. mn.

A possibility is considered of studying the asymptotic behavior of the scattering amplitudes in the complex energy plane. It is shown that if the scattering amplitudes increase exponentially in the complex plane, an accurate experimental determination of the cross sections in the physical region allows one to estimate the amplitude growth in the complex plane and may yield thereby some information concerning the elementary length in quantum field theory. (auth)

**972** ROLE OF LEVINSON'S THEOREM FOR PARTIAL WAVES WITH $l > 0$. Lyth, D. H. (Univ. of Birmingham, Eng.). Phys. Rev. Lett., 17: 830-2(Oct. 10, 1966).

It is shown that the p-wave elastic scattering amplitude

$F = [\eta \exp(2i\delta) - 1]/2iq^3$, which satisfies in the physical region the relation $ReF(s) = F_L(s) + P/\pi \int_{s_t}^{\infty} ds'[ImF(s')/(s' - s)]$, where $F_L$ is the left-hand-cut contribution and $s_t$ is the physical threshold, satisfies Levinson's theorem $[\delta(\infty) = 0]$ if and only if the functions $F_L$ and N satisfy a certain integral condition. (B.G.D.)

**973** MANDELSTAM ITERATION IN A REALISTIC BOOTSTRAP MODEL OF THE STRONG-INTERACTION S-MATRIX. Bali, Naren F.; Chew, Geoffrey F.; Chu, Shu-yuan (Univ. of California, Berkeley). Contract W-7405-eng-48. Phys. Rev., 150: 1352-7(Oct. 28, 1966). (UCRL-16774).

The Mandelstam iteration is analyzed for a strip model of the four-line connected part that conforms to most known strong-interaction experimental requirements at both high and low energies. It is shown that, with the Froissart limit as a supplementary condition, asymptotic behavior is controlled by Regge poles, the amplitude being meromorphic in the right-half angular-momentum complex plane. The results support the practicality of the Mandelstam iteration as a numerical technique for realistic bootstrap computations. (auth)

**974** PERTURBED BOUND-STATE POLES IN POTENTIAL SCATTERING. II. Kim, Y. S. (Univ. of Maryland, College Park); Vasavada, Kashyap V. Phys. Rev., 150: 1236-40(Oct. 28, 1966).

The problem of maintaining the locality of the bound-state wave function is discussed in the S-matrix approach to the first-order energy shift. It is shown first that the nearby-singularity prescription in the Dashen-Frautschi formalism leads to the inclusion of unphysical terms coming from the nonlocal component of the wave function. It is pointed out that the infrared divergence of Dashen and Frautschi comes from this unphysical term. An alternative method based on the Gelfand-Levitan formalism of the inverse-scattering problem is presented. An approximate solution of the Gelfand-Levitan equation is discussed that leads to a localized bound-state wave function. It is pointed out that this wave function gives the first-order energy shift without the infrared difficulty. Using soluble exponential potentials, numerical accuracies of this approach are discussed. (auth)

**975** ANALYTICITY CONSTRAINTS ON UNEQUAL-MASS REGGE FORMULAS. Goldberger, Marvin L.; Jones, C. Edward (Princeton Univ., N. J.). Contract AF49(638)-1545. Phys. Rev., 150: 1269-75(Oct. 28, 1966).

A Regge-pole formula is derived for the elastic scattering of two unequal-mass particles that combines desirable l-plane analytic properties (i.e., a simple pole at $l = \alpha$ in the right-half l plane) and Mandelstam analyticity. It is verified that such a formula possesses the standard asymptotic Regge behavior $u^{\alpha(s)}$ even in regions where the cosine of the scattering angle of the relevant crossed reaction may be bounded. The simultaneous requirements of l-plane and Mandelstam analyticity enforce important constraints, and the consistency of these constraints is studied. These considerations lead to the appearance of a "background" term proportional asymptotically to $u^{\alpha(0)-1}$ which has no analog in the equal-mass problem. It is also concluded that a necessary condition for consistency is $\alpha(\infty) < 0$. (auth)

**976** INVERSE SQUARE POTENTIAL FIELD. Guggenheim, E. A. (Univ. of Reading, Eng.). Proc. Phys. Soc. (London), 89: 491-3(Nov. 1966).

By the sole use of elementary considerations it is shown that for a particle in an inverse square potential field there are no discrete energy levels. (auth)

## Particle Accelerators

*Refer also to abstracts 98, 359, and 360.*

**977** (BNL-10664) MEASUREMENT ON A MULTI-STEM DRIFT TUBE STRUCTURE. Giordano, S.; Hannwacker, J. P. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT-30-2-GEN-16. 23p. (CONF-661021-5). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

A new standing wave structure, operating in the $TM_{010}$ mode, for accelerating protons below an energy of 200 MeV is discussed. This structure employs more than one stem to support each drift tube, and unlike the conventional drift tube structure the stems play a significant role in shaping the dispersion curve about the operating $TM_{010}$ mode. For the past year, an investigation into the detuning effects in linac cavities has been conducted at Brookhaven. The operating characteristics of a multistem structure are described in detail. (auth)

**978** (BNL-10665) THE RF SYSTEM FOR THE AGS 200-Mev LINAC. Sheehan, J.; Witkover, R. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT-30-2-GEN-16. 7p. (CONF-661021-9). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

A new injector for the AGS will be built with a design output current of 100 ma at 200 MeV. A prototype r-f system for this linac is being built as a basis for final design. A description of this system is given. (auth)

**979** (BNL-10666) THE EFFECT OF QUADRUPOLE FRINGING FIELDS ON COUPLING IN LINACS. Gluckstern, R. L. (Brookhaven National Lab., Upton, N. Y.). Sept. 7, 1966. Contract AT-30-2-GEN-16. 8p. (CONF-661021-6). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

The distortion of the transverse phase spaces due to fringing fields in the magnets of the strong focusing system was obtained. For a beam with fixed circular symmetry there is essentially no change in the radial oscillation amplitude. For a beam with rectangular cross section, there will be an increase in each transverse oscillation amplitude by of the order of 20% for typical linac designs. (B.G.D.)

**980** (BNL-10667) TRANSVERSE BEAM GROWTH DUE TO LONGITUDINAL COUPLING IN LINEAR ACCELERATORS. Gluckstern, R. L. (Brookhaven National Lab., Upton, N. Y.). Sept. 1, 1966. Contract AT-30-2-GEN-16. 14p. (CONF-661021-7). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

Coupling of the longitudinal and transverse motion takes place through the phase dependence of the r-f defocusing force and the radial dependence of the longitudinal transit time factor. Both of these effects arise from the same term in the Lagrangian. An analysis is presented that yields a result for the second order term which takes into account higher order terms in the first coupling term. This result appears to be in general agreement with the orbit computations and can be used as the basis for predicting transverse beam growths due to the coupling. (B.G.D.)

**981** (BNL-10668) SPACE CHARGE EFFECTS IN PROTON LINEAR ACCELERATORS. Gluckstern, R. L. (Brookhaven National Lab., Upton, N. Y.). Sept. 7, 1966. Contract AT-30-2-GEN-16. 12p. (CONF-661021-8). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

The effects of high space charge on both the longitudinal and transverse motions were investigated in order to see whether these effects will be serious for the particular parameters of the planned 200-MeV linac. (B.G.D.)

**982** (BNL-10669) NUMERICAL CALCULATIONS OF COUPLING EFFECTS IN A LOW ENERGY PROTON LINAC. Chasman, R. (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT-30-2-GEN-16. 12p. (CONF-661021-2). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

A brief description of numerical calculations on the coupling effects mentioned by Gluckstern, namely coupling between the longitudinal and transverse motions and coupling between transverse motions due to the quadrupole fringing fields is given. In the former case, only the influence on the transverse motion was considered. Most of the machine parameters used were present design values of the 200 MeV injector linac for the AGS conversion program. Only ±± quadrupole configurations were considered. No space charge effects were included. (B.G.D.)

**983** (CEA-R-2975) ETUDE DU RAYONNEMENT AUTOUR D'UN ACCELERATEUR DE HAUTE ENERGIE. PRODUCTION ET DIFFUSION DES NEUTRONS DE CASCADE. (Study of the Radiation Around a High Energy Accelerator. Production and Scattering of Cascade Neutrons). Tardy-Joubert, Philippe (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Mar. 16, 1966. 61p. Dep. mn.

Thesis. Submitted to Paris Univ. (France). Faculte des Sciences.

The cascade induced in protective screens by a 3 Gev proton beam was studied using activation detectors; the results were compared with the cosmic neutron spectrum in the atmosphere. A study of the secondary neutron spectrum has made it possible to obtain the distribution of the dose and to determine the maximum permissible fluxes expressed in terms of the energy, taking into account all the daughter products present. The dose calculated was checked experimentally. The propagation of cascade neutrons was studied using the idea of an imaginary source. The parameters which have to be introduced into the general equations to take into account scattering in the air were determined. (auth)

**984** (CEAL-1032) STORAGE RING FOR OBTAINING SYNCHROTRON RADIATION WITH LINE SPECTRA. Robinson, Kenneth W. (Cambridge Electron Accelerator, Mass.). Sept. 19, 1966. Contract AT(30-1)-2076. 12p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

It appears possible to design a very small electron storage ring in which line spectra in the optical synchrotron radiation could be obtained. These lines would be related to harmonics of the orbital frequency. This device could be used to measure the velocity of light to very high accuracy. Also the lines would be very coherent light sources for experiments on photon statistics. The effects of betatron and synchrotron oscillations, due to gas scattering and quantum effects, on the spectrum of optical synchrotron radiation are analyzed, and the results applied to a possible design of the ring. (auth)

**985** (JINR-P-2818) IZMERENIE TOPOGRAFII MAGNITNOGO POLYA SINKHROFAZOTRONA OIYAI DATCHIKAMI KHOLLA. (Measurement of the Topography of the Synchrophasotron Magnetic Field of the JINR by Hall Generator). Dement'ev, E. A.; Issinskii, I. B.; Kulakova, E. M.; Myznikov, K. P.; Polak, M.; Khovanets, F. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). 1966. 20p. Dep. mn.

The results of measurements of the synchrophasotron magnetic field of the JINR in the average geometric plane are given. The measurements were performed with the help of Hall generator at the magnetic field of 1230 G with the accuracy ±0.3%. (auth)

**986** (JINR-P-2852-1) RAZRABOTKA MAGNITNOI SISTEMY ELEKTRONNOI MODELI RELYATIVISTSKOGO TSIKLOTRONA (EMRTS). (Designing of Magnetic System of Relativistic Cyclotron Electron Model). Vorozhtsov, S. B.; Zaplatin, N. L.; Rybalko, V. S.; Sarkisyan, L. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 24p. Dep. mn.

The designing of the magnetic system of the 700-MeV relativistic cyclotron electron model intended for the experimental investigation of the modified resonance method of particle extraction is discussed. (auth)

**987** (JINR-P-2854) RASCHET DVIZHENIYA IONOV V TSENTRAL'NOI OBLASTI TSIKLOTRONA PRI POVOROTE ISTOCHNIKA. (Calculations of the Ion Motion in the Central Region of Cyclotron With Azimuthal Displacement of the Source). Kozlov, S. I.; Ogaiesyan, R. Ts.; Pek Den Gi; Shelaev, I. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Reactions). 1966. 17p. Dep. mn.

The influence of azimuthal displacement of the ion source on the acceleration process in 150 and 300 cm cyclotrons is studied. It is shown that lengthening of the first half revolution by 20° decreases the spread in orbit centers, and, hence, the spread in energy, which allows one to make the extraction more effective. The position of the ion source with respect to the magnetic center of the accelerator and the electrode geometry of the central region are determined. (auth)

**988** (JINR-P-2880) METOD RASCHETA TRAEKTORII VYVEDENNYKH CHASTITS V RASSEYANNOM POLE SINKHROFAZOTRONA OIYAI. (Method of Calculation of the Charged Particle Trajectory in the Synchrophasotron Magnetic Field of the JINR). Kulakova, E. M.; Myznikov, K. P.; Smirnova, L. A.; Feoktistov, B. V. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1966. 14p. Dep. mn.

The method is suggested of calculation of the charged particle trajectory in the synchrophasotron magnetic field of the JINR, taking into account nonlinear terms when finding the field components. (auth)

**989** (LA-DC-8247) DESIGN, DEVELOPMENT, AND FABRICATION OF MULTICAVITY 805 MHz ACCELERATOR TANKS. Worstell, H. G. (Los Alamos Scientific Lab., Univ. of California, N. Mex.). Sept. 7, 1966. Contract W-7405-eng-36. 21p. (CONF-661021-11). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

The development of full scale 805 Mc tank models for the proposed LAMPF accelerator is discussed. Topics included are materials, machining, joining techniques, allowable stresses (especially at elevated temperatures), quality control, heat transfer, and the provision of an evacuation system capable of maintaining a good clean high vacuum under full power operation. (B.G.D.)

**990** (LA-DC-8248) CIRCUIT ANALOG TECHNIQUES FOR ANALYSIS OF RESONANTLY-COUPLED LINEAR ACCELERATOR STRUCTURES. Swain, G. R. (Los Alamos Scientific Lab., Univ. of California, N. Mex.). Sept. 2, 1966. Contract W-7405-eng-36. 21p. (CONF-661021-10). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Linear Accelerator Conference, Los Alamos, N. Mex.

The application of the circuit analog to the study of resonantly-coupled accelerator structures is discussed. Topics included are the circuit analog; relation of error analysis with direct coupling present to the analysis without direct coupling; and circuit analog experiments by digital computer, effect of increasing the coupling at the drive, effect of a temperature gradient along a chain of cavities, and effect of coupling chains together to form a long chain with multiple drives. (B.G.D.)

**991** (LNF-66/28) COMPENSAZIONE DEGLI EFFETTI DEL DISACCORDO NELLE CAVITA' RISONANTI DELLE MACCHINE ACCELERATRICI. (Compensation of the Detuning Effects in the Resonating Cavity of an Accelerator). Note No. 322. Fabiani, D.; Puglisi, M. (Laboratori Nazionali di Frascati, Comitato Nazionale per l'Energia Nucleare (Italy)). May 24, 1966. 20p. Dep. mn.

Resonators are used in storage rings to maintain the particles in orbit. The amplitude and the phase of the electric field must be kept constant in these resonators. The difficulties encountered are examined. A simple solution for these problems is indicated. The functioning of the final amplifier-cavity group is analyzed, and

a correction circuit is given. Experimental results indicate that this control circuit makes it possible to compensate completely the effects of dephasing on the amplitude and phase of the input voltage. (J.S.R.)

**992** (ORNL-P-2357) MAGNET DEVELOPMENT FOR THE 50-Mev SOC. Hudson, E. D.; Lord, R. S.; Mann, J. E.; McDaniel, F. E. (Oak Ridge National Lab., Tenn.). [nd]. Contract W-7405-eng-26. 19p. (CONF-660720-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Symposium on Separated Orbit Cyclotrons and Beam-Cavity Interactions, Weston-on-the-Green, England.

A full-scale prototype sector magnet, which constitutes one sector of a proposed 12-sector 10-50 MeV SOC, was completed and preliminary tests were run to establish the magnet efficiency and magnet power for the system. (B.G.D.)

**993** (ORNL-P-2358) THE 4-Mev EXPERIMENTAL SOC: DESIGN DETAILS. Hudson, E. D.; Mann, J. E.; Martin, J. A.; McDaniel, F. E.; Mosko, S. W.; Richardson, E. G. Jr.; Worsham, R. E.; Ziegler, N. F. (Oak Ridge National Lab., Tenn.). [nd]. Contract W-7405-eng-26. 18p. (CONF-660720-2). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From Symposium on Separated Orbit Cyclotrons and Beam-Cavity Interactions, Weston-on-the-Green, England.

The novel design features of the 4-MeV SOC multi-energy, multi-particle accelerator are discussed. Topics include the magnet system, r-f system, and the injector. (B.G.D.)

**994** (PPAD-597D) FURTHER ENGINEERING DETAILS FOR FLAT-TOPPING THE PRINCETON-PENNSYLVANIA MAGNET. Huttar, D. (Princeton-Pennsylvania Accelerator, Princeton, N. J.). Aug. 17, 1966. Contract AT(30-1)-2137. 35p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The system philosophy for flat-topping the PPA synchrotron, which has evolved, is presented. The results of engineering and model study efforts are discussed. (B.G.D.)

**995** (UJV-1563) INITIAL TRAJECTORIES OF IONS OBTAINED FROM THE RADIAL INJECTION OF FAST NEUTRAL PARTICLES INTO THE CYCLOTRON CENTER. Bejsovec, V.; Hrda, A.; Kuzmiak, M. (Ustav Jaderneho Vyzkumu, Ceskoslovenska Akademie Ved, Rez). July 1966. 18p.

Initial trajectories of protons leaving a thin foil made from suitable material are investigated. The foil is situated between the cyclotron dees. Protons formed during the passage of fast hydrogen atoms are further accelerated. The problem is being solved in the connection with the problem of accelerating polarized protons and deuterons in cyclotron type accelerators. (auth)

**996** ELLIPSOIDAL DISTRIBUTION OF VELOCITIES IN A MAGNETIC FIELD. Movsesyan, R. E. Vestn. Moskov. Univ., Ser. III: Fiz. Astron., No. 3, 21-6(May-June 1965). (In Russian).

The ellipsoidal functions of the velocity distributions in a non-stationary axial-symmetrical magnetic field and the distribution of densities of charged particles in the dipole magnetic field were examined. (tr-auth)

**997** STEPPER MAGNET WITH 20 CHANNELS FOR PREVENTING SUPERIMPOSITION OF TRACKS IN BUBBLE CHAMBER. Faltens, Andris; Barale, John (Univ. of California, Berkeley). Contract W-7405-eng-48. Rev. Sci. Instrum., 37: 1463-7(Nov. 1966). (UCRL-16780).

A 20-channel "stepper" magnet assembly designed to cause the incoming Bevatron particle beam to scan across the 1.83 m hydrogen bubble chamber in discrete steps is described. The purpose of this device is to avoid superimposing tracks. Stepping was triggered by an "events" counter placed in the beam. The system was built with low voltage, silicon controlled rectifiers. Magnet pulsing was accomplished in two parts, rapid rise of field was produced by a fast circuit and pulse length was maintained by a slow circuit. Cost was approximately $15,000, exclusive of the surplus components. (auth)

**998** BEAM OPTICS COMPUTATION FOR PARTICLE TRANSPORT SYSTEMS BY MEANS OF AN IMPROVED NEWTON-RAPHSON METHOD. Bassetti, M.; Buonanni, R. M.; Placidi, M. (CNEN, Rome). Nucl. Instrum. Methods, 45: 93-101(1966).

Computation methods for beam transport systems design are exposed. The IBM 7040 code, by which the beam injection system for the Adone storage ring was designed, is also described. The name of the program is SYTRAN. (auth)

**999** NORMAL MODES OF CURRENT LOOP IN AXIALLY SYMMETRIC MAGNETIC FIELD. Smythe, Rodman (Univ. of Colorado, Boulder). Rev. Sci. Instrum., 37: 1616(Nov. 1966). (UCOL-535-555).

Recently a method of determining the tension in the case of a closed ion trajectory in a static magnetic field by measuring the frequency of stretched string vibrations was reported by R. W. Leonard et al., (Bull. Am. Phys. Soc., 10: 1190(1965)). It is shown that the usual expression for the vibrating frequency of a stretched string is not generally valid in this case, and the exact expression is derived for the frequency of small amplitude vibrations when there are two nodes in the loop and the magnetic field has axial and median plane symmetry. In this particular mode the loop behaves as if it were rigid and rocks about a diameter. (B.G.D.)

**1000** TRANSVERSE COHERENT RESISTIVE INSTABILITIES OF AZIMUTHALLY BUNCHED BEAMS IN PARTICLE ACCELERATORS. Courant, Ernest D. (Brookhaven National Lab., Upton, N. Y.); Sessler, Andrew M. Rev. Sci. Instrum., 37: 1579-88(Nov. 1966). (UCRL-16751).

The transverse electromagnetic coupling of bunches of particles with each other is investigated theoretically, and shown to incorporate the possibility (due to the effect of imperfectly conducting vacuum chamber walls) of coherent instability even when the longitudinal distance between bunches is much larger than the transverse dimensions of the vacuum tank. The modes of oscillation in which the bunches move rigidly are investigated; criteria for stability, and expressions for the small amplitude growth rates under unstable conditions are presented. The case of a single bunch is considered in detail and demonstrated to be stable (even in the absence of Landau damping) provided $\nu$ lies between an integer and the next higher half-integer, where $\nu$ is the number of transverse free betatron oscillations occurring in one revolution; for many bunches which are sensibly different in intensity (a criterion for this is presented), all modes are stable provided $\nu$ satisfies the same restriction. For equally spaced bunches of equal numbers of particles, approximately half the modes are unstable without Landau damping. Numerical examples are presented covering some intermediate situations. (auth)

**1001** HIGH-CURRENT DUOPLASMATRON ION SOURCE WITH FERRITE PERMANENT MAGNETS. Christensen, L. J.; Zaharis, E. J. (Univ. of California, Livermore). Contract W-7405-eng-48. Rev. Sci. Instrum., 37: 1571-3(Nov. 1966). (UCRL-14964).

A duoplasmatron ion source capable of producing about 12 mA of hydrogen ions was constructed and tested. The source uses ferrite permanent magnets and a low voltage Pierce type extraction lens system. (auth)

**1002** HYDROGEN ION ACCELERATOR. Dyachkov, B. A.; Nasonov, A. V. Prib. Tekh. Eksp., No. 2, 17-18 (Mar.-Apr. 1966). (In Russian).

Descriptions are given of a direct action accelerator with a high-frequency ion source in which the continuously accelerated hydrogen ion current reached 6 mA at U $\simeq$ 450 kV. The accelerator may be used as an intensive generator of monochromatic neutrons (2.5 MeV to $3 \times 10^{10}$ neut/sec and 14 MeV up to $10^{12}$ neut/sec) and also for investigations in plasma physics. (R.V.J.)

**1003** SUPERCONDUCTING WAVE GUIDES FOR ELECTRON ACCELERATORS. Combe, Rene; Alaux, Andre (Paris Univ., Puy-de-Dome, France). Compt. Rend., Ser. B, 263: 531-3(Aug. 22, 1966). (In French).

It was previously proposed that the application of superconductivity should permit the continuous operation of electron linear accelerators. Two types of wave guides, charged by circular irises and destined for such accelerators, were constructed and studied. (tr-auth)

**1004** PRODUCTION OF SHORT PULSES OF ACCELERATED ELECTRONS AND THE REGISTRATION OF THEIR MOMENT OF EXIT FROM LINEAR ACCELERATORS. Demchishin, V. I.; Komarov, L. S.; Chirkin, V. A. Prib. Tekh. Eksp., No. 2, 196-7(Mar.-Apr. 1966). (In Russian).

Descriptions are given of electron beam bunching in linear accelerator and of a zero time transducer used for producing 30-nsec pulses of accelerated electrons and a stable recording of their moment of exit to the target. (tr-auth)

**1005** COMPUTATION FOR PULSED MAGNETIC FIELD COILS. Barkov, L. M.; Ogurtsov, V. V.; Khakimov, S. Kh. (Inst. of Nuclear Energy, Moscow). Prib. Tekh. Eksp., No. 2, 137-46(Mar.-Apr. 1966). (In Russian).

The magnetic field distribution, current density, heat exchange, and other properties of a cylindrical coil were computed. The coil can produce a pulsed magnetic field of up to 200 k gauss in ~0.5 liter volume and is used (along with a beryllium-bronze unit) for measuring the magnetic moments of hyperons and the asymmetry coefficients in $\mu^+ \rightarrow e^+$ decay. (G.O.Y.)

**1006** CONSTRUCTION OF QUADRUPOLE LENS SYSTEMS HAVING A TRANSFER MATRIX OF UNITY. Moeller, Peter-Achim; Dhuicq, Daniel; Septier, Albert (Paris Univ., Orsay, France). Compt. Rend., Ser. B, 263: 534-7 (Aug. 22, 1966). (In French).

It is shown that no symmetrical doublet, triplet, (or quadruplet) can in any case whatsoever make a real image plane correspond to a real object plane with a transfer matrix M = ±1. It is suggested that the antisymmetric quadrupole can provide physically realizable solutions. (tr-auth)

**1007** THIN-FAST VALVE (Engineering Materials). (Stanford Linear Accelerator Center, Calif.). (CAPE-1483).

83 drawings.

A stainless steel, all-metal gate type, automatic, remotely controlled 6 in. valve capable of closing in ~10 μsec is used in high radiation fields in the beam switchyard area of the Stanford Linear Accelerator. A spring accumulator system located in the pneumatically controlled, aluminum cylinder piston assembly permits automatic connection and retraction of the gate mechanism. Solenoid magnetic action initially triggers the gate acceleration when a signal level electronic pulse is received from the detection transducers. Open-closed position indication is achieved by microswitching lights, and meters in the master control room. Actuation of each valve can be made for circuit check purposes. (For details, see TID-4100 Suppl. 37.) (F.S.)

**1008** CIRCULAR ACCELERATOR FOR CHARGED PARTICLES. Petersilka, Franz; Schittenhelm, Rudolf; Weiss, Robert (to Siemens-Reiniger-Werke AG). German Patent 1,222,602. Aug. 11, 1966. Filed July 25, 1964.

The accelerator comprises an evacuated accelerating tube and means for controlling the pressure of the residue gas in this tube, which are able to maintain a pressure between $10^{-5}$ and $10^{-7}$ torr independent of possible leaks or gas sources within the tube. The pressure is reduced by suitable control of the pumping speed of the high vacuum pumps. (Gmelin Inst.)

# PHYSICS (NUCLEAR)

## Neutron Interactions with Matter

*Refer also to abstract 832.*

**1009** (BNL-10585) ACTIVITIES OF THE CROSS-SECTION COMPILATION AND EVALUATION CENTERS AT THE BROOKHAVEN NATIONAL LABORATORY. Chernick, Jack (Brookhaven National Lab., Upton, N. Y.). [1966]. Contract AT(30-2)-Gen-16. 7p. (CONF-661014-2). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From IAEA Conference on Nuclear Data, Paris, France.

A summary of activities in the compilation and evaluation of neutron cross sections is presented. (D.C.W.)

**1010** (GA-7427) TIME-OF-FLIGHT MEASUREMENTS OF NEUTRON SPECTRA IN $^{235}U$ AND TUNGSTEN. Profio, A. E.; Young, J. C.; Crosbie, K. L.; Hackney, R.; Antunez, H. M.; Russell, J. L. Jr. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Sept. 22, 1966. Contract AT(04-3)-167. 31p. (CONF-661019-2). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From International Conference on Fast Critical Experiments and Their Analysis, Argonne, Ill.

The pulsed-source, time-of-flight method was used to measure neutron angular flux spectra to 15 MeV from a spherical $^{235}U$ metal critical assembly and spheres of tungsten. The object of the $^{235}U$ experiment was to test calculational methods for fast reactor spectra and the model for neutron inelastic scattering. The tungsten spectra were measured at 300°K and 800°K, as part of a current program to measure the effect of Doppler broadening on spectra. The principal features of the experimental technique are discussed, particularly time resolution, beam extraction, and detectors. The $^{235}U$ sphere measurements are presented and are compared with GAPLSN calculations. The spectrum is very close to that in a critical reactor, but there is a discrepancy between theory and experiment. The tungsten results show a clear difference between hot and cold, even to high energies. The difference can not be explained by the density change, and it is apparently the result of Doppler broadening scattering resonances. Calculations do not take this into account. (auth)

**1011** (ORNL-TM-1547) CALCULATIONS OF THE TRANSPORT OF NEUTRONS FROM FISSION AND 14-Mev POINT SOURCES IN AN INFINITE MEDIUM OF AIR. Straker, E. A. (Oak Ridge National Lab., Tenn.). Aug. 9, 1966. Contract W-7405-eng-26. 19p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Calculations by various investigators of first-collision doses and energy spectra due to neutrons from fission and 14-MeV point sources in an infinite medium of air are compared with each other and with Monte Carlo and discrete-ordinate calculations. In the Monte Carlo calculations for the 14-MeV source, the sensitivity of the dose and spectral results to the manner in which inelastic scattering was treated in the calculations was investigated. It is concluded that the significant differences in the calculated doses and energy spectra for both fission and 14-MeV sources cannot be traced to differences in the calculational techniques alone, but that they may be due to variations in the cross sections used in the calculations. Varying the treatment of inelastic scattering led to wide variations, indicating the importance of obtaining accurate inelastic cross-section data. (auth)

**1012** THE USE OF ALUMINUM, LEAD, GERMANIUM, AND COPPER AS MONOCHROMATING CRYSTALS FOR NEUTRONS. Broecker, B. (Univ., Kiel). Atomkernenergie, 11: 381-4(1966). (In German).

The neutron reflectivity of the crystals aluminum, lead, germanium, and copper was computed following the equations of Bacon for several lattice reflections. Results are given in diagrams. The intensity of reflected neutrons for the first three orders and an incoming Maxwell spectrum of 320°K was also computed in the angular range 3–45° and compared with measurements. (auth)

**1013** MEASUREMENT OF MEAN EMISSION TIME AND OTHER MISCELLANEOUS SPECTRA MEASUREMENTS. Cerbone, R. J.; Gozani, T.; Malaviya, B. K.; Gaerttner, E. R. 8p. (CONF-660606-42). ORAU. Gmelin, AED-CONF-66-203-114.

From American Nuclear Society Meeting, Denver.

The mean emission time of neutrons in a homogeneous paraffin–$^{235}U$–$ZrO_2$ assembly was measured using the pulsed-source time-of-flight technique. (D.C.W.)

**1014** RELATIVE MERITS OF IMPULSE AND MODULATED SOURCES IN THERMAL NEUTRON WAVE EXPERIMENTS. Booth, Ray S. (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio); Perez, Rafael B.; Hartley, Robert 4p. (CONF-660606-22). ORAU. Gmelin, AED-CONF-66-203-54.

From American Nuclear Society Meeting, Denver, Colo.

An experiment was performed to determine the amplitude and phase of neutron waves at several frequencies as a function of penetration through graphite for both a sinusoidal source and an impulse source. It was found that data could be obtained at deeper penetrations with an impulse source. A graph is given of the amplitude vs. penetration depth for both the wave and pulse propagation experiments at various frequencies. (S.F.L.)

## Nuclear Properties and Reactions, $A \leq 5$

**1015** (AD-634756) NEUTRON FORM FACTORS FROM INELASTIC ELECTRON SCATTERING IN TRITIUM AND $^3He$. Hughes, E. B.; Yearian, M. R.; Hofstadter, R. (Stanford Univ., Calif. High-Energy Physics Lab.). May 1966. Contract Nonr-225(67). 23p. (HEPL-443). CFSTI $1.00 cy, $0.50 mn.

Measurements are reported of the inelastic scattering of electrons from the mirror nuclei of tritium and $^3He$. The ratio of the quasi-elastic electron–tritium and electron–$^3He$ cross sections was measured to a precision of about 3% for values of the square of the four-momentum transfer, equal to 2.5 and $4.6/F^2$. Detailed measurements of the shape of the entire inelastic spectra and estimates of the total inelastic cross sections were made. While these data are primarily intended to furnish additional experimental information which will be of use in determining the structure of the three-body nuclei, it is also pointed out that such data are a possible source of information on the structure of the neutron. (auth)

**1016** (UCRL-16991) PROTON-PROTON SCATTERING BETWEEN 4.2 AND 10 Mev AND THE $^1S_0$ SHAPE DEPENDENT SCATTERING PARAMETERS. Slobodrian, R. J.; Conzett, H. E.; Shield, E.; Tivol, W. F. (Lawrence Radiation Lab., Univ. of California, Berkeley). July 1966. Contract W-7405-eng-48. 12p. (CONF-660906-30). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Conference on Nuclear Physics, Gatlinburg, Tenn.

Proton-proton scattering angular distributions were measured at 6.141, 8.097, and 9.981 MeV (laboratory energy) in an experiment designed to achieve an absolute accuracy better than 1%. A phase-shift analysis has produced preliminary values for the $^1S_0$ phase shifts, as well as split P and $^1D_0$ phase shifts. With this new information it is possible to reach substantially less ambiguous conclusions concerning the shape-dependent parameters P and Q than was possible before. (auth)

**1017** (WANL-TME-1492) NEUTRON INTERFERENCE SCATTERING IN CRYSTALLINE SOLIDS. Progress

Report. Johnston, A. S. (Westinghouse Electric Corp., Pittsburg, Pa. Astronuclear Lab.). Aug. 1966. Contract SNP-1. 36p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The literature was studied to determine the principles, the methods, and the current results of calculations of inelastic neutron scattering from polycrystalline beryllium and graphite and to determine the agreement that has been obtained between calculations and measurements of the elastic and inelastic neutron scattering cross section. The principles by which the inelastic scattering cross section is calculated are outlined, some of the Born-Von Karman models proposed for hexagonal lattices are described, and methods of numerically evaluating the inelastic scattering cross section formulas are discussed. (auth)

**1018** NUCLEAR INTERACTIONS OF ANTIPROTONS WITH ALUMINIUM AND CARBON. Bell, W. C.; Brandt, R.; Chackett, K. F.; Neale, W. W.; Ravn, H. L. (CERN, Geneva). Z. Naturforsch., 21a: 1042-7(July 1966).

The reactions leading to the production of $^{11}C$ from $^{12}C$ and $^{27}Al$, and of $^{18}F$ from $^{27}Al$ were studied with antiprotons and negative pions of momentum (2.5–3.0) BeV/c. No significant differences were found in the cross-section ratios. The experimental uncertainties are in the order of 25%. (auth)

**1019** INTERMEDIATE-STRUCTURE STRENGTH FUNCTION. Bolsterli, M.; Gibbs, W. R.; Kerman, A. K.; Young, J. E. (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. Lett., 17: 878-80(Oct. 17, 1966).

Measurement of the two-particle one-hole or doorway-state strength function by suitable averaging of (d,p) and (p,p′) cross sections is proposed. (auth)

**1020** SINGLE-NUCLEON EMISSION FOLLOWING THE ABSORPTION OF FREE PIONS. Letourneux, J.; Eisenberg, J. M. (Univ. of Virginia, Charlottesville). Nucl. Phys., 87: 331-6(1966). (ORO–2915-58).

The absorption of a free pion by an uncorrelated nucleon in a complex nucleus is considered. The process is treated in terms of perturbation theory, and the distortions of the incident and outgoing waves are neglected. Differential and total cross sections for single-nucleon emission from a given shell are presented in the cases of $^{12}C$ and $^{16}O$. (auth)

**1021** TENSOR POLARIZATION OF DEUTERONS IN ALPHA-DEUTERON ELASTIC SCATTERING. Young, P. G.; Ohlsen, G. G.; Ivanovich, M. (Australian National Univ., Canberra). Nucl. Phys., 6701A: No. 1, 41-55 (1967).

The spin tensor moments $\langle T_{20} \rangle$, $\langle T_{21} \rangle$, and $\langle T_{22} \rangle$ of deuterons from alpha-deuteron elastic scattering were measured at 12 energy-angle combinations for angles of 120, 135, and 180° (cms) and for alpha energies between 4.4 and 11.1 Mev. The experimental results are in reasonable agreement with values computed from the phase shifts of McIntyre and Haeberli although some quantitative differences do exist. Four additional measurements were made at angles of 66.5 and 85.8° (cms) for deuteron energies between 4.2 and 5.7 MeV and are consistent with previous experimental data. (auth)

**1022** REACTION $^4He(^3He,n)^6Be$. Gulyamov, M.; Rybakov, B. V.; Sidorov, V. A. Yadern. Fiz., 4: 93-6 (July 1966). (In Russian).

The neutron spectrum for the reaction $^4He(^3He,n)^6Be$ is investigated for the $^3He$ ion energy 29.8 ± 0.3 MeV, using a fast neutron multichannel spectrometer, according to the time of flight. Neutron groups were detected, corresponding to the ground and first excited state of the $^6Be$ nucleus. The energy ($E^* = 1.73 \pm 0.1$ MeV) and width ($\Gamma = 1.7 \pm 0.3$ MeV) of the $^6Be$ excited state were determined. The differential cross sections for the production of both neutron groups were measured for the angles 0°, 7.5°, 15°, 22.5°, 30°, and 45°, with respect to the incident $^3He$ ion beam. (auth)

**1023** DOPPLER SHIFT DETERMINATION OF LIFETIMES FOR COULOMB EXCITED STATES. Nordhagen, R. (Univ. of Oslo); Elbek, B.; Herskind, B. 8p. (CONF-660411–48). ORAU. Gmelin, AED-CONF-66-060-99.

From American Physical Society Meeting, Washington, D. C.

For a Coulomb excitation process the distribution of recoil directions and velocities can be calculated exactly, and consequently the exact shapes of the spectra of gamma rays from the recoiling nuclei can be calculated. The usual Doppler-shift attenuation method can then be used for determination of nuclear lifetimes without selection of recoil direction by a coincidence arrangement. A computer program was constructed for calculation of the spectrum shapes for various ratios of the nuclear lifetimes to the slowing-down time for the recoil. Nuclear lifetimes from $5 \times 10^{-14}$ to $5 \times 10^{-12}$ sec can then be inferred from the gamma spectra recorded by a Li-drifted Ge detector. An analysis of spectra from Coulomb excitation by oxygen ions yield lifetimes in $^{63}Cu$ of 0.26 psec for the 668-keV state and 0.82 psec for the 961-keV state. In $^{59}Co$ preliminary lifetimes of 0.08 psec for the 1189-keV state and >4 psec for the 1097-keV state were obtained. (auth)

**1024** SCATTERING OF POLARIZED PROTONS BY HELIUM FROM 0.9 TO 3.2 Mev. Brown, Louis (Carnegie Inst. of Washington, D. C.); Traechslin, Walter. 11p. (CONF-660411–51). ORAU. Gmelin, AED-CONF-66-060-125.

From American Physical Society Meeting, Washington, D. C.

Protons from a pressure tank electrostatic generator with a source of polarized ions were scattered from $^4He$. The left-right asymmetry was observed at 110 points for energies from 0.94 to 3.2 MeV and for laboratory scattering angles from 30° to 140°. (auth)

**1025** HIGH ENERGY NEUTRON SCATTERING FROM LIQUID $^4He$. Hohenberg, P. C.; Platzman, P. M. (Bell Telephone Labs., Inc., Murray Hill, N. J.). 13p. (CONF-660327–11). ORAU. Gmelin, AED-CONF-66-050-32.

From American Physical Society Meeting, Durham, N. C.

An experiment is proposed using high-energy neutrons to probe the momentum distribution of helium atoms in liquid helium and to detect the presence of a zero-momentum condensate below $T_\lambda$. It is suggested that for momentum transfers to the neutron much larger than a roton momentum, the energy transfer should be equal to the recoil energy of a single helium atom, Doppler shifted by its initial motion in the helium bath. Thus, if a finite fraction of atoms are initially in the zero-momentum state, they will contribute a peak to the spectrum of scattered neutrons. Corrections due to final-state interactions are discussed briefly and are estimated. (auth)

## Nuclear Properties and Reactions, $6 \leq A \leq 19$

*Refer also to abstracts 1019, 1020, 1022, 1023, and 1124.*

**1026** (AD-628932) INELASTIC SCATTERING AT 45.5 MeV PROTONS FROM Be AND C. Petersen, Edward (California Univ., Los Angeles. Dept. of Physics). Jan. 1966. Contract Nonr-233(44). 76p. (TR-P-74). CFSTI $7.60 cy, $0.75 mn.

The differential cross sections for the excitation of nine levels of carbon and one level of beryllium are reported for 35 angles from 15 to 150°. The results for the 2.43-MeV level of beryllium and the 4.4- and 9.6-MeV levels of carbon have an average relative accuracy of 3% while the 7.6-, 10.8-, 11.8-, 12.7-, 14.0-, 15.1-, and 16.1-MeV levels of carbon have an average accuracy of 10%. The cross sections change by one to three orders of magnitude from forward to backward angles. Levels at 13.3 and 16.6 MeV in carbon were not observed. The experimental apparatus is described, and the 2.43-, 4.4-, 7.6-, and 9.1-MeV angular distributions are compared with distorted-wave calculations. (TAB)

**1027** (JINR–P-2901) ISSLEDOVANIE MEKHANIZMA RADIATSIONNOGO ZAKHVATA $\pi^-$-MEZONOV SLOZHNYMI YADRAMI. (Investigation of the Mechanism of $\pi^-$-Meson Radiative Capture by Complex Nuclei). Petrukhin, V. I.; Pogosov, V. S.; Prokoshkin, Yu. D. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 19p. Dep. mn.

It is proved by the experiment that neutron escape in the direction opposite to that of $\gamma$ quantum takes place at the radiative capture of $\pi^-$ mesons by the Li nuclei. All the peculiarities of the observed process agree with the assumption about one-nucleon mechanism of the radiative capture of $\pi^-$-mesons by nuclei. (auth)

**1028** (ORNL–TM–1567) NUCLEON TRANSFER IN $^{14}N + ^{10}B$ AND $^{14}N + ^{40}Ca$ REACTIONS. Couch, Jack Gary (Oak Ridge National Lab., Tenn.). Sept. 1966. Contract W-7405-eng-26. 128p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

Thesis. Submitted to Texas Agricultural and Mechanical Univ., College Station.

The results of an investigation of the neutron-transfer reactions $^{10}B(^{14}N,^{13}N)^{11}B$ and $^{40}Ca(^{14}N,^{13}N)^{41}Ca$ and of the proton-transfer reaction $^{10}B(^{14}N,^{11}C)^{13}C$ are presented. The experimental results are compared with theoretical predictions. (D.C.W.)

**1029** (ORNL–TM–1665) SOME RECENT NUCLEAR CROSS SECTION MEASUREMENTS AT ORNL, MARCH 1–SEPTEMBER 30, 1966. Stelson, P. H. (Oak Ridge National Lab., Tenn.). Oct. 11, 1966. Contract W-7405-eng-26. 21p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Measurements on neutron inelastic scattering by Al, Ca, C, Co, Fe, K, Na, V, and Y; the differential scattering of neutrons by O; the neutron total cross section of N from 2.0 to 4.2 MeV; and the neutron total cross section of $^{40}Ca$ from 1.0 to 2.1 MeV are summarized. A computer program GRAP for the analysis of neutron-capture gamma spectra is also briefly described. (D.C.W.)

**1030** ODD-PARITY STATES OF $^{16}O$ WITH THE HAMADA-JOHNSTON POTENTIAL. Mavromatis, H. A. (Princeton Univ., N. J.); Markiewicz, W.; Green, A. M. Contract AT(30-1)-937. Nucl. Phys., 6701A: No. 1, 101-12(1967). (PUC–937-209).

Odd-parity states of $^{16}O$ are calculated using matrix elements of the Hamada-Johnston nucleon-nucleon force. Also estimates are made of the effects of higher configurations, variable separation distances, and the presence of the Coulomb interaction. (auth)

**1031** DISTORTED MOMENTUM DISTRIBUTIONS FROM QUASI-ELASTIC PROTON-PROTON SCATTERING IN CARBON AT 160 Mev. Gottschalk, B.; Wang, K. H.; Strauch, K. (Harvard Univ., Cambridge, Mass.). Nucl. Phys., 6701A: No. 1, 83-100(1967).

The quasi-elastic reaction $^{12}C(p,2p)^{11}B(159.6$ Mev) was investigated in a way designed to study the dependence of cross section on the recoil momentum of the residual nucleus, predicted by the "knock-out" model. Specifically, the usual "coplanar-symmetric" experiment was extended to include events in which the energies of the outgoing protons are not equal; thus cases in which the primary p-p interaction is noncollinear are observed. The distorted momentum distributions of p- and s-state protons calculated from cross sections measured over a wide range of outgoing proton energies and angles are in general quite consistent. On the other hand, certain distortions of the momentum distributions are evident; these may be due to refraction of waves at the nuclear surface. The over-all reduction of cross section due to absorptive effects is in reasonable agreement with several predictions. The fraction of events leading to certain low-lying excited states of the residual $^{11}B$ nucleus is estimated. (auth)

**1032** A DETERMINATION OF THE TRANSITION WIDTHS OF SOME EXCITED STATES IN $^{12}C$. Crannell, Hall; Griffy, T. A.; Suelzle, L. R.; Yearian, M. R. (Stanford Univ., Calif.). Contract Nonr-225(67). Nucl. Phys., 6701A: No. 1, 152-8(1967).

Previous measurements of the transition probabilities for low-energy excitations in $^{12}C$, using high-energy electron scattering techniques, required considerable extrapolation of the data to obtain the desired results. The present paper reports the results of data obtained at lower values of momentum transferred to the nucleus. Transition widths for the three lowest-energy excited states in $^{12}C$ are determined using the data. The results of the experiment allow a much greater confidence in the method employed in this study for determining transition widths. (auth)

**1033** THE MUON CAPTURE BY $^{11}B$ TO THE TWO LOWEST LEVELS OF $^{11}Be$. Rood, H. P. C. (CERN, Geneva). Nucl. Phys., 87: 367-75(1966).

The partial rates for the capture of muons in $^{11}B$ for the transitions to the two lowest levels of $^{11}Be$ are calculated with the simple shell model. Although a comparison of the theoretical with the experimental result for the ground state to ground state beta decay shows that only qualitative agreement is expected, it turns out that the experiment on muon capture can provide useful information on the first excited state of $^{11}Be$, especially on its parity. (auth)

**1034** ANALYTIC THEORY OF SUBCOULOMB STRIPPING. II. COMPARISONS WITH EXPERIMENTAL DATA. Morinigo, Fernando B. (California Inst. of Tech., Pasadena. California State Coll., Los Angeles). Nucl. Phys., 6701A: No. 1, 113-21(1967).

The analytic formulas developed in earlier publications for the analysis of stripping reactions are applied to the reactions $^{12}C(d,p)^{13}C^*$ (3.09) at 11 deuteron energies, $^{10}B(d,p)^{11}B^*$ (9.19) at five lab energies, and $^{10}B(d,p)^{11}B^*$ (9.28) at six bombarding energies. It is found that a reaction amplitude expressed as a sum of a pure stripping Coulomb wave part plus s-wave and p-wave corrections is indeed capable of describing the angular distributions satisfactorily, not only in the region of the main peak, but at all angles, and at bombarding energies for which conventional plane-wave and distorted-wave theories fail. The spectroscopic factors determined at various bombarding energies have a variance which can be entirely explained as the expected variance due to experimental errors and estimated uncertainties in the absolute values of the cross sections; hence the spectroscopic factor determined is a constant over the energy range of the measurements. The adjustable parameters of this theory, which in an equivalent DWBA treatment would represent the real and imaginary parts of certain radial integrals, are found to have an acceptable magnitude and to be rather slowly varying with energy. (auth)

**1035** DIRECTIONAL CORRELATION MEASUREMENTS IN $^{18}O(^3He,p\gamma)^{20}F$. Bissinger, G. A.; Mueller, R. M.; Quin, P. A.; Chagnon, P. R. (Univ. of Notre Dame, Ind.). Nucl. Phys., 6701A: No. 1, 1-12(1967).

Directional $p\gamma$ correlations through the first six excited levels of $^{20}F$ were measured in an axially symmetric reaction geometry at $^3He$ energies of 3.3 to 3.8 MeV. Interpretation of the correlations leads to probable spin assignment of 3 and 2 for the 0.66- and 0.83-MeV levels, respectively. Possible spin assignments for the 0.99-, 1.06-, 1.31-, and 1.85-MeV levels and multipole mixing ratios in the corresponding transitions are discussed. Branching ratios of the 0.83- and 1.85-MeV levels are reported. (auth)

**1036** A STUDY OF THE $^9Be(^3He,t)^9B$ AND $^9Be(^3He,^3He)^9Be$ REACTIONS. Earwaker, L. G. (California Inst. of Tech., Pasadena). Nucl. Phys., 6701A: No. 1, 56-64 (1967).

Excitation functions, angular distributions, and absolute cross sections were measured. An excitation function for the ground state tritons from the $^9Be(^3He,t)^9B$ reaction was measured at a lab angle of 20° over the energy range from 3.5 to 9.0 MeV, and angular distributions were measured at 1-MeV intervals between 5.0 and 9.0 MeV. The elastic scattering excitation function was measured at a lab angle

of 45° over the energy range from 4.0 to 9.0 MeV, and angular distributions were taken at 6.0 and 8.0 MeV. The ground states of $^{9}$Be and $^{9}$B are isobaric analogues and as such have the same quantum numbers, differing only in the orientation of isospin in isospin space. The ($^{3}$He,t) angular distributions were therefore compared with the predictions of an optical model which includes an isospin-dependent potential proportional to (t · T), where t and T are the isospins of the projectile and target, respectively. Appropriate distorted potentials for the incoming and outgoing channels were determined from fits to the elastic scattering distributions. (auth)

**1037** BETA-GAMMA AND BETA-ALPHA ANGULAR CORRELATIONS IN THE DECAY OF $^{8}$Li AND $^{8}$B. Eichner, H. (Univ., Cologne); Lauterjung, K. H.; Meinhardt, H.; Schimmer, B.; Schmidt-Rohr, U. Z. Naturforsch., 21a: 908-13(July 1966). (In German).

The $\beta$-$\gamma$ and $\beta$-$\alpha$ angular correlations for the decay of $^{8}$Li → $^{8}$Be* → 2$\alpha$ previously studied were remeasured with an improved experimental setup. In addition these correlations for the decay $^{8}$B → $^{8}$Be* →2$\alpha$ were measured. Values obtained for the coefficient b in the angular correlation between $\beta$, $\gamma$, and $\alpha$ particle for Gamow-Teller interaction $[W(b,\vartheta,\varphi)d\Omega = [(1 + b\ v/c)\cos\vartheta \cdot \cos\varphi]\ d\Omega]$ where $b(^{8}Li) = -1.01 \pm 0.07$ and $b(^{8}B) = 1.05 \pm 0.12$. Both results are in agreement with pure axial vector interaction. Values for the coefficient B in the angular correlation between $\beta$ and $\alpha$ particles, $[W(\Theta)\ d\Omega = (1 + A \cdot \cos\Theta + B \cdot \cos^2\Theta)\ d\Omega]$ were $B(^{8}Li) = (+0.0031 \pm 0.0003) \cdot W_{\beta}$ and $B(^{8}B) = (-0.0023 \pm 0.0003) \cdot W_{\beta}$. The experimental result $\delta = B(^{8}Li) - B(^{8}B) = (0.0054 \pm 0.0004)\ W_{\beta}$ is within the range predicted by the conserved vector current theory. (auth)

**1038** EXCITATION OF $2^{+}$ STATES IN EVEN NUCLEI BY INELASTIC DEUTERON SCATTERING. Jahr, R.; Santo, R. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 964-8(July 1966). (In German).

Some regularities in the experimental angular distributions of inelastically scattered deuterons ($E_d \sim 11.8$ MeV) corresponding to the lowest $2^{+}$ states of the even nuclei $^{12}$C, $^{20}$Ne, $^{22}$Ne, $^{24}$Mg, $^{26}$Mg, $^{28}$Si, $^{32}$S, $^{40}$A, Ti, $^{52}$Cr, Fe, $^{58}$Ni, Zn, Kr, Sr, and Zr are discussed. Blair's phase rule is approximately valid for strongly deformed nuclei in the region of $^{24}$Mg, whereas it is not valid for the other nuclei. The latter also results from DWBA calculations which have been carried out for nuclei with mass number $A \geqq 40$, using a real coupling potential. Several different sets of optical parameters have been used for the calculations and it is found that the extracted deformation parameters depend considerably on the choice of the optical potential. (auth)

**1039** ISOSPIN IN $^{8}$Be. Paul, P. (Stanford Univ., Calif.). Z. Naturforsch., 21a: 914-28(July 1966).

Many experiments indicate that isospin is not a good quantum number for the states with $J^{\pi} = 2^{+}$ at 16.6 MeV and 16.9 MeV in $^{8}$Be. The available experimental information is examined and compared with a model of single particle states which are maximally mixed in isospin, as proposed by Marion. An analysis of all data pertinent to the states at 17.6 MeV and 18.15 MeV with $J^{\pi} = 1^{+}$ shows that these states are rather pure (90%) isospin states. The state at 17.6 MeV has T = 1, the one at 18.15 MeV has T = 0. Both the $2^{+}$ and the $1^{+}$ levels form doublets with similar wave functions in each case. A similar pair is most likely formed by the $3^{+}$ states at 19.05 MeV and 19.22 MeV, as proposed by Barker. Reduced widths indicate possible isospin mixing of as much as 30% for these states. Some experimental evidence is presented for another pair of states with $J^{\pi} = 1^{-}$ at 20.35 MeV and 22 MeV, and with $J^{\pi} = 2^{-}$ at 18.9 MeV and 23.6 MeV. This hypothesis provides analog states in $^{8}$Be for every state observed in $^{8}$Li in the energy region which is considered. If each pair (except the $1^{+}$ and $2^{+}$ pairs) is allowed to mix isospin by at most 30%, all cases of large excess of either neutron or proton reduced width can be explained. The large isospin mixture in the $2^{+}$ pair can be explained on the basis of an initial energy degeneracy of these states (removed by the Coulomb force). The intermediate coupling shell model does account for such an accident. It is argued that, although a simple cluster picture of these states is highly successful in a qualitative way, the intermediate coupling model is able and probably needed to achieve a quantitative description of $^{8}$Be between 16 and 20 MeV. (auth)

**1040** STUDY OF ELECTROMAGNETIC TRANSITIONS IN $^{207}$Tl, $^{13}$C, $^{12}$B, AND $^{53}$Mn BY THE METHODS OF ANGULAR CORRELATIONS, ANGULAR DISTRIBUTIONS, AND PLANE POLARIZATION OF $\gamma$ RAYS. Beck, Francis. Ann. Phys. (Paris) (14), 1: 503-36(July-Aug. 1966). (In French).

Nuclear characteristics of the isotopes $^{207}$Tl, $^{13}$C, $^{12}$B, and $^{53}$Mn were determined by measuring $\gamma$-ray angular distributions, angular correlations, and plane polarizations from electromagnetic energy-level transitions. The complete experimental arrangements and associated theory are given. (S.F.L.)

**1041** MEASUREMENT OF THE ANGULAR DISTRIBUTIONS OF THE REACTION $^{14}$N(d,$\alpha$)$^{12}$C. Euringer, H.; Neuert, H.; Schoelermann, H. (Univ., Hamburg). Z. Naturforsch., 21a: 977-9(July 1966). (In German).

Angular distributions of the reaction $^{14}$N(d,$\alpha$)$^{12}$C were measured in the energy region from 0.5 to 2.2 MeV at 9 different deuteron energies. The measured values were approximated by the Legendre polynomial. The analysis indicated the existence of at least 3 levels. (tr-auth)

**1042** ON THE BEHAVIOR OF A "GHOST" PEAK SEEN IN THE REACTION $^{6}$Li($^{3}$He,p). Lorenz, Th. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 1196-8(July 1966).

The reaction $^{3}$He + $^{6}$Li → p + $^{8}$Be → p + 2 $^{4}$He was investigated using the $^{3}$He beam of a tandem Van de Graaff accelerator. Proton spectra were measured using solid-state detectors protected against particles with Z = 2 by thin Al absorbers. Variations in the proton spectra were checked by covering the easily attainable angular and energy range. The reaction angle was varied between 15 and 165°, and the energy of the incident beam was varied between 5.5 to 18.0 MeV. Data points were taken at intervals of $\Delta\Theta \leq 15°$ and angular distributions at energy intervals $\Delta E = 0.5$ MeV. Apart from the characteristic behavior of the differential cross section, the appearance of a rather pronounced "ghost" peak was observed in the proton spectra. The maximum energy of this peak corresponded to 0.8-MeV excitation in $^{8}$Be. This peak was seen only at bombarding energies between 10 and 11 MeV and at reaction angles of at least 155°. (S.F.L.)

**1043** ELASTIC SCATTERING OF $^{14}$N ON $^{9}$Be AT 25 Mev AND $^{16}$O ON $^{11}$B AT 30 Mev. Oertzen, W. v.; Bock, R.; Grosse-Schulte, M. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 946-9(July 1966).

The elastic scattering of $^{14}$N on $^{9}$Be at 25 MeV and $^{16}$O on $^{11}$B at 30 MeV has been measured and analyzed with optical model and ingoing-wave boundary condition calculations. Acceptable fits were obtained for the angular region below 100° c.m. The reflection coefficients derived from these calculations are compared with the diffraction model calculations of Dar for the corresponding p- and $\alpha$-transfer reactions, in which a Woods-Saxon distribution of the reflection coefficients is used. (auth)

**1044** SPECTRA OF NEUTRONS AND GAMMA RAYS FROM Po−$\alpha$−Be AND Po−$\alpha$−B SOURCES MEASURED IN ($n,\gamma$)-COINCIDENCE. Bakov, A. T.; Blyumkina, Yu. A.; Dvukhsherstnov, V. G.; Dulin, V. A.; Kazanskii, Yu. A.; Kamaeva, L. A. Vienna, International Atomic Energy Agency, 1966, Preprint No. SM-76/52, 14p. (In Russian). (CONF-660807-8). ORAU.

From Symposium on Neutron Monitoring for Radiological Protection, Vienna.

The authors present the energy spectra of neutrons and the recorded spectra of gamma rays from Po−$\alpha$−Be and Po−$\alpha$−B sources measured by a system of fast-slow coin-

cidences. As the neutron detector they used a single-crystal fast neutron scintillation spectrometer with discrimination of gamma rays during de-excitation. A single-crystal scintillation spectrometer with a NaI(Tl) crystal was used as the gamma ray detector. From the experimental results they obtain the energy spectrum of neutrons from the Po–$\alpha$–Be source without interference by the 4.44-MeV gamma rays, determine the relationship between the neutrons and the 4.44-MeV gamma rays, and demonstrate the possibility of measuring the absolute activity of Po–$\alpha$–Be sources. The results are compared with those obtained by other authors. (auth)

**1045** ISOBARIC ANALOG RESONANCES IN LIGHT NUCLEI. Jaffe, A. A.; Harchol, M. (Hebrew Univ., Jerusalem). 8p. (CONF-660306-19). ORAU. Gmelin, AED-CONF-66-048-22.

From American Physical Society, Conference on Isobaric Spin, Tallahassee.

Many isobaric analog states have been identified in the published literature in medium-weight nuclei by observation of resonances in the excitation functions of (p,p), (p,p′), (p,$\gamma$), and (p,n) reactions, the measurements being restricted to target nuclei no lighter than $^{48}$Ca. These resonances are the analogs of levels observed in the (d,p) reaction on the same target nucleus which have a large reduced width for neutrons. It is shown that the published data on (p,$\gamma$), (p,p), and (d,p) reactions can be used to identify analog resonances in light nuclei ($A \leq 40$). (S.F.L.)

## Nuclear Properties and Reactions, $20 \leq A \leq 89$

*Refer also to abstracts 1019, 1020, 1023, 1028, 1035, 1038, 1040, 1045, 1120, and 1124.*

**1046** (RPI-328-70) NEUTRON RADIATIVE CAPTURE MEASUREMENTS AT THE RENSSELAER POLYTECHNIC INSTITUTE'S ELECTRON LINAC. Block, R. C. (Oak Ridge National Lab., Tenn. Rensselaer Polytechnic Inst., Troy, N. Y.); Hockenbury, R. W.; Bartolome, Z.; Fullwood, R. R. (Rensselaer Polytechnic Inst., Troy, N. Y.). [1965]. Contract AT(30-3)-328. 23p. (CONF-661014-3). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From IAEA Conference on Nuclear Data, Paris, France.

Neutron radiative capture measurements were carried out on Na, Al, Fe, $^{56}$Fe, $^{57}$Fe, $^{58}$Fe, Ni, $^{58}$Ni, $^{60}$Ni, $^{61}$Ni, and $^{64}$Ni using equipment capable of resolving resonance structure up to a few hundred keV. By combining an efficient capture detector with an intense pulsed electron linear accelerator, extreme sensitivity was obtained for detecting resonances with small neutron widths which are frequently missed in transmission measurements. It is demonstrated that these small-width resonances contribute significantly to capture in the neutron energy range of fast reactors. The rather large number of resonances with small widths suggests that p-wave or d-wave neutrons are responsible for the observed resonances. (S.F.L.)

**1047** NUCLEAR EXCITATION FUNCTIONS BY 13 Mev DEUTERONS. Cheng, Xiao-wu; Wang, Zhen-xia; Wang, Zhen-chieh; Yang, Chin-cheng. Wu Li Hsueh Pao, 22: 250-2(Feb, 1966). (In Chinese).

The reactions $^{65}$Cu(d,2n)$^{65}$Zn, $^{64}$Zn(d,p)$^{65}$Zn + $^{64}$Zn(d,n) $^{65}$Ga → $^{65}$Zn, and $^{52}$Cr(d,2n)$^{52}$Mn were studied using deuterons accelerated to 13.04 MeV in a cyclotron. A review of the experimental uncertainties in the flow measurements, unevenness in the thickness of the targets, and the behavior of the detectors indicated that the absolute error was less than 10% and that the relative error about 5%. Statistical calculations concerning the first reaction, based on a nuclear temperature T = 1.1 MeV and a nuclear energy density $\delta$ = 0.5 MeV, agree with the low-energy experimental results but yielded higher values than the experimental data at high-energy end; this may be due to the start of direct interactions. The results for the second reaction were close to those reported by J. W. Irvine; the peaks of the experimental curve and experimental data point to a direct-interaction type of mechanism. Data on the third reaction are inconclusive because the production rate of the most stable isotope $^{52}$Mn was not included. (TTT)

**1048** CAPTURE OF NEGATIVE MUONS BY PURE Ni AND Cr ISOTOPES. Bobrov, V.; Varlamov, V.; Grashin, Yu.; Dolgoshein, B.; Kirillov-Ugryumov, V.; Nikitin, Yu.; Roganov, V.; Samoilov, A.; Somov, S. (Moscow Inst. of Engineering Physics). Yadern. Fiz., 4: 75-82 (July 1966). (In Russian).

Experimental results on the time for the capture of negative muons by $^{58}$Ni, $^{60}$Ni, $^{62}$Ni, $^{50}$Cr, $^{52}$Cr, $^{53}$Cr, and $^{54}$Cr are described. They are discussed and compared with theoretical calculations based on the nuclear shell model and the theory of finite Fermi-systems. (auth)

**1049** CROSS SECTIONS OF $^{40}$Ca PHOTONEUTRON REACTIONS. Bazhanov, E. B.; Komar, A. P.; Kulikov, A. V.; Ogurtsov, V. I. (Ioffe Inst. of Physics and Tech., Leningrad). Dokl. Akad. Nauk SSSR, 167: 1263-5(Apr. 21, 1966). (In Russian).

Experiments were performed on the cross sections of photoneutron reactions with the $^{40}$Ca nucleus from the threshold of ($\gamma$,n) reactions (15.62 MeV) to 50 MeV. The yield of photoneutrons vs maximal $\gamma$-ray retardation-spectrum energy $E_{\gamma max}$ was measured with a recording interval of 1 MeV. The results are presented graphically. The curve of the photoneutron reaction cross sections in the $^{40}$Ca nucleus has, in addition to a gigantic resonance at slightly below 22 MeV, maxima in the energy-level ranges 22.5 to 24.0 MeV and 26 to 28 MeV. There may also be a wide maximum at about 33 MeV. Both the 22.5 to 24.0 and 26 to 28 MeV peaks are above the ($\gamma$,pn) reaction threshold and may possibly correspond to this reaction. The 26 to 28 MeV maximum was not noted earlier in studies of the ($\gamma$,n) reaction. The results of other experimental and theoretical works in the area are mentioned briefly. (JPRS)

**1050** $^{28}$Si($^3$He,$\alpha$)$^{27}$Si REACTION AT 15 Mev. Swenson, L. W. (Franklin Inst., Swarthmore, Pa.); Zurmuehle, R. W.; Fou, C. M. Nucl. Phys., 6701A: No. 1, 232-40 (1967).

Measurements were made of the angular distributions of alpha particles from the $^{28}$Si($^3$He,$\alpha$)$^{27}$Si reaction leading to the ground state and the 0.78, 0.96, 2.17, 2.65, 2.87, and 2.91 MeV excited states of $^{27}$Si. The angular distribution of 15-MeV $^3$He elastically scattered from $^{28}$Si was also measured. DWBA analysis of the angular distributions was carried out, and spectroscopic factors were extracted. The results indicate the presence of considerable configuration mixing in the ground state of $^{28}$Si. (auth)

**1051** LIFETIMES OF LEVELS IN $^{21}$Ne. Bent, R. D. (Indiana Univ., Bloomington. Atomic Energy Research Establishment, Harwell, Eng.); Evans, J. E.; Morrison, G. C.; Gale, N. H.; Van Heerden, I. J. Nucl. Phys., 6701A: No. 1, 122-34(1967).

Attenuated Doppler shifts were measured for the decay of the levels in $^{21}$Ne at 1.74, 2.80 and 2.87 MeV using 24-MeV $^{16}$O ions and the reaction $^9$Be($^{16}$O,$\alpha\gamma$)$^{21}$Ne. From these results, the mean lifetimes of the 1.74- and 2.87-MeV levels were found to be, in units of $10^{-13}$ sec, 1.5 and 1.1, respectively. The observed Doppler shift for the decay of the unresolved doublet at 2.80 MeV is consistent with the recent lifetime limits and branching ratios given by Smulders and Alexander for levels at 2.790 and 2.797 MeV. The data are combined with branching ratio and multipole mixing ratio data to obtain the partial mean lifetimes of eight transitions in $^{21}$Ne. The results are discussed in terms of the systematics of transitions in the 2s-1d shell and in terms of several nuclear models. The lifetimes and branching ratios of the 1.74- and 2.87-MeV levels are consistent with the predictions of the Nilsson model with K-band mixing for spin and parity assignments of $\frac{7}{2}^+$ and $\frac{9}{2}^+$, respectively, to these two levels. The results for the 2.797-MeV level are consistent with the predictions of the Nilsson model, the Chi-Davidson asymmetric core model and the Dreizler excited core model if a $\frac{1}{2}^+$ spin and parity assignment is made to this level. However, the results for the 2.790-MeV

level are inconsistent with its interpretations as the $5/2^+$ level predicted in this energy region by the Nilsson and Dreizler models, since these models overestimate the M1 transition probabilities for decay by several orders of magnitude and fail to give the correct branching ratio. (auth)

**1052** SCANDIUM 51. Bizzeti-Sona, A. M.; Messlinger, R.; Morinaga, H. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 906-7(July 1966).

Previously unreported decay characteristics of $^{51}$Sc were studied. The activity was obtained from a series of bombardments of an enriched $^{48}$Ca target (in the carbonate form) with 18-MeV $\alpha$ particles. Beta particle measurement of the sample indicated a component of ~5 MeV end-point energy which decays with a half life of 12 sec. Gamma-ray measurements gave new lines at 1.44 and 2.16 MeV, both decaying with a half life of ~12 sec. The $\gamma$-ray energies coincide with some of the energies of the states observed in $^{51}$Ti from the $^{50}$Ti(d,p) reaction, and the $\beta$ end-point energy is in agreement with the known Q value of the $^{48}$Ca($\alpha$,p)$^{51}$Sc reaction. All decay characteristics are quite consistent with theoretical predictions. (auth)

**1053** THE STANDARDIZATION OF $^{57}$Co. Garfinkel, S. B.; Hutchinson, J. M. R. (National Bureau of Standards, Washington, D. C. Int. J. Appl. Radiat. Isotop., 17: 587-93(Oct. 1966).

A method is described for standardizing radioactive $^{57}$Co for the total disintegration rate. Systematic errors due to maximum uncertainties in the decay scheme are estimated to be less than 0.6 percent. (auth)

**1054** DECAY OF $^{60}$Cu. Schumacher, M.; Schoeneberg, R.; Flammersfeld, A. (Univ., Goettingen, Ger.). Z. Phys., 196: 298-310(1966). (In German).

The $\gamma$ spectrum of $^{60}$Ni associated with the electron-capture and $\beta^+$ decay of $^{60}$Cu was measured with Ge(Li)-crystals. The observed $\gamma$ transitions led to a level-scheme for this decay with $^{60}$Ni levels at: 1332, 2159, 2286, 2627, 3125, 3196, 3272, 3391, 4025, 4080, 4332, 4500, 4554, and 4584 keV, most of which could be identified with previously reported levels found in scattering experiments. As far as possible, spin and parity assignments were made; and the levels were compared with phonon and quasi-particle theory. (auth)

**1055** THE DECAY OF $^{88}$Nb. Flegenheimer, J. (Kernforschungszentrum, Karlsruhe, Ger.). Radiochim. Acta, 6: 20-6(Aug. 1966).

With deuteron and alpha bombardments of natural zirconium and yttrium targets, respectively, $^{88}$Nb could be identified. The mass number was established by milking the daughter nuclide. The half life of $^{88}$Nb is 13.6 min, and $\gamma$ lines of 75, 270, 400, 670, 1058, and 1080 keV are produced during its decay. Relative intensities of the $\gamma$ lines and their coincidences were studied. The 75-keV line was found to be appreciably converted. A possible decay scheme is presented and compared to those of $^{90}$Zr and $^{86}$Sr. A 3.2-min half life was found in the niobium fraction from a 100-MeV $\gamma$-bombardment on yttrium. (auth)

**1056** DETERMINATION OF THE COMPOUND ELASTIC EFFECTIVE CROSS SECTION FOR THE ELASTIC SCATTERNG OF PROTONS ON $^{54}$Cr AND $^{56}$Fe FOR INCIDENT ENERGIES BETWEEN 9 AND 12 Mev. Ernst, J.; Harney, H. L.; von Brentano, P.; Mayer-Kuckuk, T. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 950-7(July 1966). (In German).

Excitation functions of proton elastic scattering on the even-even nuclei $^{54}$Cr and $^{56}$Fe were measured at incident proton energies from 9.3 to 10.11 MeV in 5 keV steps and from 9.27 to 9.57 MeV in 2 keV steps respectively, and from 11.5 to 11.9 MeV in 5 keV steps for $^{56}$Fe(p,$p_0$) only. Seven silicon surface barrier detectors were used to get angular distributions from 63° to 173°. The observed cross-section fluctuations are interpreted in terms of Ericson's statistical theory. From the strength of the fluctuations, differential compound elastic cross-sections are deduced. The results are compared with Hauser-Feshbach calculations and are generally discussed with respect to the optical model. (auth)

**1057** A STATISTICAL MODEL ANALYSIS OF (p,$\alpha$) REACTIONS ON $^{26}$Mg, $^{37}$Cl, AND $^{45}$Sc. Richter, A.; Bamberger, A.; von Brentano, P.; Mayer-Kuckuk, T.; von Witsch, W. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 1001-14(July 1966).

The reactions $^{26}$Mg(p,$\alpha$)$^{23}$Na, $^{37}$Cl(p,$\alpha$)$^{34}$S, and $^{45}$Sc(p,$\alpha$)$^{42}$Ca were studied. Excitation functions and angular distributions were measured for proton energies 9 to 13.26 MeV, 11 to 11.952 MeV, and 8.5 to 9.412 MeV in steps of 20 keV, 8 keV, and 6 keV, and the transitions into 4, 3, and 5 final states have been resolved, respectively. All the excitation functions exhibit strong fluctuations and were analyzed in terms of the various correlation functions, from which the mean level width $\Gamma$, the normalized variance, and the amount of direct interaction contribution were derived. Statistical model calculations have been used to fit the averaged angular distributions and an attempt was made to estimate the J-dependence of the mean level width $\Gamma$ in the compound nuclei excited at about 20 MeV. (auth)

**1058** INFLUENCE OF CRYSTAL BINDING ON TOTAL NEUTRON CROSS SECTION ABOVE 10 ev FOR COPPER. Drittler, K. Atomkernenergie, 11: 385-91(1966). (In German).

The counting rates of neutrons passing through single crystals of copper were measured by the time-of-flight method in two crystallographic directions. The experiments were analyzed using a model of the crystal. It is concluded that the measured effects have a high probability of being due to crystal binding. Experimental results are presented and their significance discussed. (S.F.L.)

**1059** STUDY OF THE REACTIONS $^{20}$Ne(d,p)$^{21}$Ne AND $^{20}$Ne(d,$\alpha$)$^{18}$F AT 2 MeV. Lambert, Michel; Dumazet, Gerard; Beaumevieille, Henri (Institut d'Etudes Nucleaires, Alger, France). Compt. Rend., Ser. B, 263: 280-3(Aug. 22, 1966). (In French).

The effective absolute differential cross sections for the reactions $^{20}$Ne(d,p)$^{21}$Ne and $^{20}$Ne(d,$\alpha$)$^{18}$F were studied at 2 MeV for the groups $p_0$, $p_1$, $p_2$, $p_3$, $p_5$, and $p_7$ and for the groups $\alpha_1$, $\alpha_3$, $\alpha_5$, and $\alpha_6$. The probable values for the neutron momentum transfer for these groups are indicated as well as the pertinent spectroscopic factors. (tr-auth)

**1060** ANOMALY IN THE ENERGY DEPENDENCE OF THE ANGULAR DISTRIBUTIONS FOR DEUTERONS SCATTERED FROM $^{24}$Mg IN THE ENERGY RANGE FROM 6 TO 13 Mev. Mayer-Boericke, C.; Siemssen, R. H. (Argonne National Lab., Ill.). Z. Naturforsch., 21a: 958-63(July 1966).

Angular distributions for elastic and $2^+$ inelastic deuteron scattering from $^{24}$Mg were obtained at various energies in the range from 6 to 13 MeV. Yield functions were measured in 50 keV steps at 90° and 150°. In the region from 10 to 13 MeV, the elastic angular distributions show an anomalous behavior; instead of moving in from 180°, a new maximum is created by the breakup of a broad maximum at about 100° into two maxima. The inelastic angular distributions do not show such an anomalous energy dependence. Therefore the Blair phase rule between the elastic and the $2^+$ inelastic angular distributions breaks down in the energy region of the anomaly in the elastic scattering, but it holds outside this energy region. In spite of fluctuations in the excitation functions, an optical-model analysis of the elastic angular distributions yields parameters which, with the exception of W, vary smoothly with energy. (auth)

**1061** USE OF PROMPT GAMMA ENERGY YIELD TO ESTIMATE THE 14 Mev $^{51}$V(n,2n)$^{50}$V CROSS SECTION. Williams, J. R.; Western, G. T.; Carter, H. G. (General Dynamics/Fort Worth, Tex.). 11p. (CONF-660606-36). ORAU. Gmelin, AED-CONF-66-203-55.

From American Nuclear Society Meeting, Denver, Colo.

A method used to estimate the cross section for the $^{51}$V(n,2n)$^{50}$V reaction at 14 MeV from the average prompt

gamma energy yield per nonelastic interaction is described. (D.C.W.)

**1062** POLARIZATION IN THE ELASTIC SCATTERING OF 49 Mev PROTONS BY Ca, $^{58}$Ni, $^{60}$Ni, AND $^{208}$Pb. Craig, R. M.; Dore, J. C.; Lowe, J.; Watson, D. L. (Univ. of Birmingham, Eng.). 14p. (CONF-650977-3). ORAU.

From Conference on Nuclear and Particle Physics, Liverpool, England.

Angular distributions are presented of the polarization produced in the elastic scattering of 49-MeV protons in the angular range from 20 to 120° (lab). Results for Ca, $^{58}$Ni, $^{60}$Ni, and $^{208}$Pb show the characteristic oscillations well-known at lower energies, but exhibit higher maximum polarizations in general. The technique used involved the single scattering of a 49-MeV polarized beam. (auth)

**1063** RECOILLESS GAMMA RAYS FROM NUCLEAR REACTIONS. Eck, J.; Goldberg, D. A.; Keaton, P. W. Jr.; Lee, Y. K.; Madansky, L.; Ritter, E. T.; Stevens, R. R. Jr.; Walker, J. C. (Johns Hopkins Univ., Baltimore). 30p. (CONF-660411-18). ORAU. Gmelin, AED-CONF-66-060-60.

From American Physical Society Meeting, Washington, D. C.

The initial experiments with $^{57}$Fe using Coulomb excitation and deuteron stripping reactions are briefly discussed, together with the relevance to radiation damage theory. Experiments on the Mössbauer effect in rare-earth nuclei using Coulomb excitation are considered in detail. (D.C.W.)

**1064** FORM FACTORS FOR INELASTIC SCATTERING OF $\alpha$ PARTICLES AND ELECTRONS FROM $^{89}$Y. Jackson, Daphne F. (Univ. of Surrey, London). 10p. (CONF-650977-1). ORAU.

From Conference on Nuclear and Particle Physics, Liverpool, England.

Calculations of the effective interaction, or form factors, for the inelastic scattering of alpha particles and electrons by $^{89}$Y are outlined and are compared with the form factors derived using a phenomenological surface-interaction model. For alpha scattering, all the form factors are very similar in the surface region; this result can be used to extract the usual deformation parameter. It is concluded that it is necessary to choose some independent means to fix the parameters of the $\alpha$-N potential and that this can be done by calculating a real optical potential and its derivative. (D.C.W.)

**1065** DECAY OF $^{62}$Zn. Roulston, K. I.; Becker, E. H. (Univ. of Manitoba, Winnipeg, Can.). 9p. (CONF-660633-8). ORAU. Gmelin, AED-CONF-66-199-20.

From American Physical Society, Division of Plasma Physics, Minneapolis, Minn.

The energy levels and decay of $^{62}$Zn were studied by the reaction $^{63}$Cu(p,2n)$^{62}$Zn. The threshold of the reaction was found to be about 15 Mev with the cross section increasing to about 150 mb at 25 Mev and decreasing to about 20 mb at 40 Mev. A natural copper target of 99.98% purity was used. Gamma-ray pulse-height spectra are given for $^{62}$Cu and $^{62}$Zn, and a level scheme is proposed for $^{62}$Cu. (S.F.L.)

**1066** ENERGY LEVELS OF $^{82}$Kr POPULATED BY $^{82}$Br DECAY. Raman, Subramanian (Pennsylvania State Univ., University Park). 31p. (CONF-758-63). ORAU. Gmelin, AED-CONF-65-003-136.

From American Physical Society Meeting, New York, Jan. 1965.

The $\gamma$ rays following the $\beta$ decay of $^{82}$Br were investigated using a 220-mm$^3$ Ge(Li) detector, an anti-Compton NaI(Tl) spectrometer, and a two-dimensional coincidence arrangement. $^{82}$Br was produced by thermal-neutron activation of ammonium bromide. The presence of eight well known and eleven weak $\gamma$ rays were established. It was shown through half-life measurements that the newly identified $\gamma$ rays belong to $^{82}$Br decay and that the high-energy peaks are not due to summing effects. All of the reported transitions were incorporated in a level scheme of $^{82}$Kr by introducing levels at 0, 776, 1474, 1820, 1953, 2093, 2426, 2554, 2647, and 2828 keV. Limits on probable spin and parity values for the newly introduced levels were established. The level introduced at 2828 keV on the basis of a 1008-1043 keV $\gamma\gamma$ coincidence must be fed by a weak $\beta$ branch of $^{82}$Br with an end-point energy of 263 keV and a log ft value of approximately 6.1. (auth)

**1067** A STUDY OF THE $^{36}$S(p,$\gamma$)$^{37}$Cl REACTION WITH BOMBARDING ENERGIES IN THE 790-keV TO 1820-keV RANGE Perrizo, J. J.; Hyder, A. K. Jr.; Harris, G. I.; Kendziorski, F. R. 52p. (CONF-651149-3). ORAU. Gmelin, AED-CONF-65-462-3.

From American Physical Society, Ohio Section, Fall Meeting, Dayton, Ohio.

The reaction $^{36}$S(p,$\gamma$)$^{37}$Cl was investigated over the energy range from 0.79 to 1.82 MeV. Approximately 80 resonance levels corresponding to $^{37}$Cl excitation energies between 9.1 and 10.2 MeV were found. Evidence for possible previously unreported levels in $^{37}$Cl at 4.5 and 5.4 MeV was obtained. (D.C.W.)

## Nuclear Properties and Reactions, A ≥ 90

*Refer also to abstracts 1019, 1020, 1023, 1038, 1040, 1062, 1063, 1125, 1145, and 1146.*

**1068** (AE-241) BURN-UP DETERMINATION BY HIGH RESOLUTION GAMMA SPECTROMETRY: SPECTRA FROM SLIGHTLY-IRRADIATED URANIUM AND PLUTONIUM BETWEEN 400–830 kev. Forsyth, R. S.; Ronqvist, N. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Aug. 1966. 23p. Dep. mn.

Previously published studies of the short-cooled fission product spectra of irradiated uranium have been severely restricted by the poor energy resolution of the sodium iodide detectors used. In this report are presented fission product spectra of irradiated uranium and plutonium obtained by means of a lithium-drifted germanium detector. The resolved gamma peaks have been assigned to various fission products by correlation of measured energy and half-life values with published data. By simultaneous study of the spectra of two irradiated mixtures of plutonium and uranium, the possibility of using the activities of $^{103}$Ru and $^{106}$Ru as a measure of the relative fission rate in $^{235}$U and $^{239}$Pu has been briefly examined. (auth)

**1069** (AERE-M-1231) THE FISSION CROSS SECTION OF $^{232}$U FROM 4eV TO 400eV. A Summary of Preliminary Results. James, G. D. (Atomic Energy Research Establishment, Harwell (England)). June 1963. 8p. Dep. mn.

The fission cross section of $^{232}$U from 4 eV to 400 eV was measured by a time-of-flight experiment. The distribution of the fission widths of seven resonances below 100 eV fits a $\chi^2$ distribution with $\nu = 2.3^{+1}_{-\frac{1}{2}}$ degree of freedom. (auth)

**1070** (ANL-7205) DAUGHTER GROWTH IN FRESHLY SEPARATED $^{226}$Ra, $^{227}$Ac, AND $^{232}$U. Stewart, D. C.; Macias, E. S.; Basile, L. J.; Milsted, J. (Argonne National Lab., Ill.). May 1966. Contract W-31-109-eng-38. 20p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The buildup of daughter nuclides is presented in both tabular and graphic form for the decay of $^{227}$Ac, $^{226}$Ra, and $^{232}$U. A computer program was written to allow the yield data to be accumulated on a CDC-3600 computer. The data were then put into a form usable by the IBM-1620 with a special "converter" program, and the machine was used to prepare the final data in graphical as well as tabular form. The data-producing programs are given. (S.F.L.)

**1071** (CONF-661012-4) THE HALF-LIVES OF $^{227}$Ac AND $^{227}$Th MEASURED CALORIMETRICALLY. Jordan, Kenneth C.; Blanke, Bertram C. (Mound Lab., Miamisburg, Ohio). [1964]. Contract AT-33-1-GEN-53. 14p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From IAEA Symposium on the Standardization of Radionuclides, Vienna, Austria.

The calorimetric half life measurement of $^{227}$Ac and of $^{227}$Th are given to show an application of the twin heat flow

calorimeters to such studies. The half life of $^{227}$Ac and probable error was determined to be 21.7728 + 0.0029/−0.0032 years (based on an ordinary tropical year of 365.2422 days), and the half life and probable error of $^{227}$Th was 18.7176 ± 0.0052 days. The $^{227}$Ac half life was determined on three samples in three calorimeters over a 14-year period. (auth)

**1072** (JINR-E-2908) THE DECAY $^{155}$Tb → $^{155}$Gd. Finger, M.; Galan, P.; Kuznetsova, M.; Liptak, Ya.; Urbanets, Ya.; Vrzal, Ya. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1966. 8p. Dep. mn.

The energies and intensities of γ-ray transitions from the decay of $^{155}$Tb → $^{155}$Gd were measured with a double-focusing β spectrometer and with a Ge(Li) semiconductor detector. The multipolarities are given and a more complete decay scheme is constructed. The admixture of E0 transitions from the odd-parity rotational band based on the level at 592 keV to the levels of the ground state band seems to indicate the vibrational nature of this level. (auth)

**1073** (JINR-P-2820) SISTEMA KOLLEKTIVNYKH UROVNEI TIPA I π K = 0$^+$0 V YADRE $^{164}$Er. (System of Collective Levels of I π K = 0$^+$0 Type in $^{164}$Er Nucleus). Vrzal, Ya.; Gromov, K. Ya.; Liptak, Ya.; Molnar, F.; Morozov, V. A.; Urbanets, Ya.; Chumin, V. G. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1966. 38p. Dep. mn.

In the study of $^{164}$Tm → $^{164}$Er decay, levels at 1245.5, 1698, 1766.1, 2170.5, and 2185.0 keV of the 0$^+$ type as well as an octupole level at 1386 keV with IπK = 1$^-$0 were identified. (auth)

**1074** (JINR-P-2839) SINTEZ IZOTOPOV 102 ELEMENTA S MASSOVYMI CHISLAMI 254, 253 I 252. (Synthesis of 102 Isotopes With Mass Numbers 254, 253, and 252). Mikheev, V. L.; Ilyushchenko, V. I.; Miller, M. B.; Polikanov, S. M.; Flerov, G. N.; Kharitonov, Yu. P. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Reactions). 1966. 19p. Dep. mn.

In bombarding $^{242}$Pu and $^{239}$Pu with $^{16}$O and $^{18}$O ions, the isotopes $^{254}$102 ($T_{½}$ = 75 ± 15s, $E_α$ = 8.11 ± 0.03 MeV), $^{253}$102 ($T_{½}$ = 95 ± 10s, $E_α$ = 8.01 ± 0.03 MeV), and $^{252}$102 ($T_{½}$ = 4.5 ± 1.5s, $E_α$ = 8.41 ± 0.03 MeV) were synthesized. The isotopes were identified by obtaining the excitation functions and by recording the α decay of the daughter nuclei. (auth)

**1075** (JINR-P-2862) IZUCHENIE SPONTANNO DELYASHCHIKHSYA PRODUKTOV V YADERNYKH REAKTSIYAKH $^{230}$Th + $^{10}$B I $^{230}$Th + $^{11}$B. (Investigation of the Spontaneously Fissionable Products in Nuclear Reactions $^{230}$Th + $^{10}$B and $^{230}$Th + $^{11}$B). Kuzletsov, V. I.; Skobelev, N. K.; Flerov, G. N. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Reactions). 1966. 8p. Dep. mn.

In the nuclear reactions $^{230}$Th + $^{10}$B and $^{230}$Th + $^{11}$B a spontaneous fission with $T_{½}$ = (2.6 + 0.2) min was recorded. The excitation functions and the production cross section of this product have been investigated. A spontaneous fission with $T_{½}$ = (1.4 + 0.25) min was observed when bombarding $^{230}$Th with $^{10}$B ions with energy of 82 MeV and above. A hypothesis was suggested that the decay with half life equal to 2.6 min is due to the spontaneous fission of $^{234}$Am from an isomeric state. The experiments were performed on the internal beam of the Y−300 cyclotron. (auth)

**1076** (JINR-P-2907) NOVYE IZOTOPY RTUTI. (New Hg Isotopes). Demin, A. G.; Makhunka, I.; Subbotin, V. G.; Tron, L.; Fenesh, T. (Joint Inst. for Nuclear Research, Dubna (USSR)). 1966. 18p. Dep. mn.

Products of the reactions $^{170}$Yb + $^{20}$Ne, $^{147}$Sm + $^{40}$Ar, and $^{169}$Tm + $^{22}$Ne were collected by absorption from a stream of He and their α radiation analyzed by a semiconductor spectrometer. The energies of the α particles, half lives of the observed emitters, and excitation functions of the reactions were measured. Five new α groups belonging to new isotopes of Hg were observed. The isotopes observed were $^{179}$Hg, $^{180}$Hg, $^{182}$Hg, and possibly $^{181}$Hg and $^{183}$Hg. Data were also obtained on the α decay of $^{185}$Hg, $^{186}$Hg, $^{181}$Au, $^{183}$Au, $^{185}$Au, $^{176}$Pt, $^{178}$Pt, $^{179}$Pt, and $^{180}$Pt which are in agreement with known results. (auth)

**1077** (LA-DC-7813) NEW TIME-OF-FLIGHT MEASUREMENTS MADE WITH AN INTENSE SOURCE. Hemmendinger, A. (Los Alamos Scientific Lab., Univ. of California, N. Mex.). [1966]. Contract W-7405-eng-36. 51p. (CONF-661014-5). Dep. mn. CFSTI $3.00 cy, $0.50 mn.

From IAEA Conference on Nuclear Data, Paris, France.

In an experiment in Nevada in June 1965 a nuclear device with a yield equivalent of 1.2 kton of TNT provided the neutron source for time-of-flight measurements over a path of 185 m in vacuo. To exploit the combination of high flux and high energy resolution, new recording techniques were required. Because more than a million data points are acquired in any one exposure of a set of targets, the general problems of data retrieval and processing required special attention. Measurements of fission cross sections of the nuclides $^{233}$U, $^{235}$U, $^{239}$Pu, $^{240}$Pu, $^{241}$Pu, $^{241}$Am, and $^{242}$Am are reported. In addition, capture-to-fission ratios of $^{233}$U and $^{240}$Pu are reported. The neutron energy range is 10 eV to 2 MeV. Individual resonances are resolved in the 100-eV range. Fission data in the resonance region are characterized by lower minima than are reported by most earlier investigators, indicating more favorable signal-to-background ratios. A unique feature of these experiments is the high rate of data acquisition, which allows cross-section measurements on short-lived nuclides. Even for the long-lived nuclides, these experiments provide an abundance of data required in current nuclear technology—data that could otherwise be acquired only by years of tedious measurement. (auth)

**1078** (NAA-SR-Memo-12102) RESONANCE PARAMETER LIBRARY FOR THE TRIX-1 CODE. Otter, J. M. (Atomics International, Canoga Park, Calif.). Aug. 2, 1966. Contract AT(11-1)-Gen-8. 27p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Resonance parameters from recent measurements and evaluations were compiled to form an updated library for the TRIX-1 code. The code was modified to print the date of revision of each isotope. The contents of the library are listed and the references for all parameters given. (auth)

**1079** (PPAD-593E) NUCLEAR CHEMISTRY RESEARCH AT PRINCETON UNIVERSITY, ANNUAL PROGRESS REPORT, 1965-1966. Thomas T. D.; Naumann, R. A.; Kaufman, S. B. (Princeton-Pennsylvania Accelerator, Princeton, N. J.). June 30, 1966. Contract AT(30-1)-2137. 64p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The decays of $^{132}$Ce, $^{135}$Ce, $^{137}$Ce, $^{132}$La, and $^{134}$La were investigated; the energy levels of $^{132}$Ba were studied through the decay of $^{132}$La. A method for separating the rare earths by ion-exchange chromatography was developed. A 20-min activity was observed in a mixture of Os and Ru and was tentatively assigned to $^{180}$Os; the presence of the 2.4-min $^{180}$Re-isomer was determined from the γ spectrum. The energy levels of $^{188}$Pt and $^{189}$Pt were investigated through the decay of $^{188}$Au and $^{189}$Au, and two negative-parity levels were located in $^{194}$Hg, $^{196}$Hg, and $^{198}$Hg from the electron-capture decay of isomeric $^{194}$Tl, $^{196}$Tl, and $^{198}$Tl. The multipolarities of some transitions in $^{194}$Hg, $^{196}$Hg, and $^{198}$Hg were also established. Angular-momentum effects in the gamma de-excitation of fission fragments were studied theoretically, as was the validity of level-density expressions for high angular momentum. The effects of angular momentum on the evaporation of alpha particles and nucleons were calculated using the statistical model. The emission of light charged particles in the fission of $^{252}$Cf was investigated experimentally, as was the production of isomeric $^{193}$Hg, $^{195}$Hg, $^{197}$Hg, $^{196}$Tl, and $^{198}$Tl in the spallation of $^{238}$U by 2.8-BeV protons. A scintillation detection system was developed to reduce the background in an Orange beta spectrometer, and isotope-

separated samples of radioisotopes were investigated using retardation collection of ions on thin wire electrodes. (D.C.W.)

**1080** (TID–23365) RANGES OF SHIELDED NUCLIDES FROM THERMAL-NEUTRON FISSION OF $^{233}U$ AND $^{235}U$. Nakahara, Hiromichi (Massachusetts Inst. of Tech., Cambridge. Dept. of Chemistry). 1966. Contract AT(30-1)-2736. 206p. Dep. mn. CFSTI $6.00 cy, $1.25 mn.

Thesis.

The range deficits in aluminum of $^{86}Rb$ and $^{136}Cs$ fission fragments were determined for $^{233}U$ and $^{235}U$ thermal-neutron fission by the thin-target, thick-catcher method. The values are 6.5 ± 1.2% and 7.9 ± 1.0% in $^{233}U$ fission and 9.4 ± 1.2% and 8.5 ± 1.0% in $^{235}U$ fission for $^{86}Rb$ and $^{136}Cs$, respectively. All the observed ranges were transformed into energies by a slight modification of the range-energy relation derived by Lindhard et al. The energy deficits for $^{86}Rb$ and $^{136}Cs$ in terms of secondary fragment kinetic energy were found to be 4 ± 1.5 MeV and 9 ± 1.5 MeV for $^{233}U$ fission, and 8 ± 1.5 MeV and 10 ± 1.5 Mev for $^{235}U$ fission, respectively. The technique of direct Ge(Li) γ-ray spectrometry was used for determination of many range values in a short time. Average ranges of 20 products in 16 mass chains were determined by this technique for $^{233}U$ thermal-neutron fission. Monte Carlo calculations were performed in an attempt to predict the energy deficits for the shielded nuclides. The calculations showed that the energy deficit for $^{86}Rb$ results from the improbable charge divisions, and thus low total energy release, for the production of $^{86}Rb$, whereas the deficit for $^{136}Cs$ is more the result of a large number of neutron emissions required for production of $^{136}Cs$. Little difference was found in the calculations between the assumptions of no correlation and positive correlation among the excitation energies of complementary fragments. But for both of these assumptions, the assumption of the excitation energy constant for a given mass division was strongly favored over that of the kinetic energy constant for a given mass division on the basis of the range deficits. Some other quantities in fission reactions are also predicted, and the assumptions used in the calculations are discussed. (auth)

**1081** (UCRL–14800) LIVERMORE PROGRAM FOR SEPARATING AND STUDYING THE PRIMARY FISSION FRAGMENTS. Stevenson, P. C.; Cambey, L. A.; Smith, T. (Lawrence Radiation Lab., Univ. of California, Livermore). July 1966. Contract W-7405-eng-48. 13p. (CONF-660817–5). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Symposium on Why and How Should We Investigate Nuclides Far Off the Stability Line, Lysekil, Sweden.

A program to develop a generally applicable technique for studying in detail the primary products of fission is described. Measurements of the half lives, decay schemes, isobaric chain yields, and average kinetic energies of the primary fission fragments over the entire mass range of fission products are being made. The technique consists in stopping fission fragments in mixtures of highly purified noble gases; transporting the stopped ions out of the reactor; passing them through a differential pumping system into a vacuum; reaccelerating and mass-separating them; and finally studying their yields and decay characteristics by suitable detectors. Information of kinetic energy of a particular isobar is derived from studying the variation of yield with fission source thickness, which gives the range of the fragment in the source material. Information on the chemical nature of the fragments can be deduced from the variation of ionic charge with noble gas mixture, since the ionic charge of the thermalized fragment will depend on the first ionization potential of the most easily ionized gas present. Times from formation of fission fragments to arrival at the detector are predicted to be of the order of a few tens of milliseconds. Equilibrium arrival rates at the detector are estimated to be large enough such that fission products over the mass range from about 75 to about 160 (for $^{238}U$) can be investigated. Experimental approaches are reported for the investigation of the generation, stability, and mobility of ions in helium at pressures approaching one atmosphere; of the effect of impurities in the gas, and the methods for achieving adequate helium purity; of the transporting of ions in helium atmospheres over distances of the order of a meter or more; and of the injection of these ions into a mass-separating system. (auth)

**1082** (UCRL–16987) ANGULAR DISTRIBUTIONS OF GAMMA RAYS EMITTED IN $^{197}Au(p,2n)^{196}Hg$ AND $^{197}Au(p,4n)^{194}Hg$ REACTIONS. Yamazaki, T.; Hendrie, D. L. (Lawrence Radiation Lab., Univ. of California, Berkeley). July 1966. Contract W-7405-eng-48. 9p. (CONF-660906–28). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Conference on Nuclear Physics, Gatlinburg, Tenn.

A study of angular distributions of gamma rays from the $^{197}Au(p,2n)$ and $^{197}Au(p,4n)$ reactions has established levels of $^{196}Hg$ and $^{194}Hg$ and determined the level spins and transition multipolarities as follow (energy in keV): 425, 2+; 1035, 2+; 1060, 4+; 1755, 5–; 1785, 6+ in $^{196}Hg$, and 426, 2+; 1061, 4+; 1795, 6+; 1808, 5–; 1907, 7– in $^{194}Hg$. (auth)

**1083** THE MULTIPOLARITY OF THE K-FORBIDDEN 1094-keV γ TRANSITION IN THE DECAY OF $^{172}Lu$. Blumberg, H.; Speidel, K.-H.; Schlenz, H.; Weigt, P.; Huebel, H.; Goettel, P.; Wagner, H.-F.; Bodenstedt, E. (Univ. of Bonn). Nucl. Phys., 6701A: No. 1, 65-82(1967).

The multipolarity of the K-forbidden 1094-keV γ transition in the decay of $^{172}Lu$ was reinvestigated by γγ angular correlation and linear polarization correlation measurements. The use of a Ge(Li) detector for the low-energy lines gave a good separation of the different cascades, and consequently more reliable results could be obtained than previous NaI(Tl) measurements had given. From the data for the multipolarity of the 1094-keV line, a mixture of 91% E2 and 9% M1 was obtained. The mixing parameter is $\delta = +3.2 \pm 0.2$. The linear polarization correlation of the 1094–79 keV γγ cascade agrees fairly well with this multipole mixture; but it is in disagreement with a measurement by Stautberg. A measurement of the circular polarization of the 1094-keV line gave $|P_c| \leq 1\%$. No evidence for a parity mixing in this transition was obtained. (auth)

**1084** SPALLATION AND FISSION FRAGMENTS OF HEAVY NUCLEI INDUCED BY 18-Gev PROTONS REGISTERED BY MEANS OF SOLID PLASTIC DETECTORS. Debeauvais, M.; Stein, R.; Ralarosy, J.; Cueer, P. (Centre de Recherches Nucleaires, Strasbourg). Nucl. Phys., 6701A: No. 1, 186-98(1967).

The reactions of 18-BeV protons with heavy nuclei were investigated using solid ionographic detectors. The sandwich-detector technique is outlined, and the possibility of the existence of three-prong events is discussed. (D.C.W.)

**1085** STUDIES OF HIGH-ENERGY NUCLEAR FISSION BY MEANS OF MICA DETECTORS. Brandt, R. (CERN, Geneva. Max-Planck-Institut fuer Kernphysik, Heidelberg); Carbonara, F.; Cieslak, E.; (and others). Nucl. Phys., 6701A: No. 1, 177-85(1967).

Nuclear fission of heavy nuclei bombarded with high-energy protons was investigated by means of mica sandwiches. Apart from single tracks resulting from spallation reactions and correlated pairs of tracks due to binary fissions, spatial coincidences of three fragment tracks were observed and were interpreted as possible examples of ternary fissions of heavy nuclei. (auth)

**1086** A DETERMINATION OF THE YIELD OF PROMPT ELECTRONS EMITTED IN THE SPONTANEOUS FISSION OF $^{252}Cf$. Kleinheinz, P.; Siegbahn, K. (Uppsala Univ.). Nucl. Phys., 6701A: No. 1, 145-51(1967).

From a coincidence measurement, the yield and the energy spectrum of conversion electrons emitted in the spontaneous fission of $^{252}Cf$ were determined. Significant results were obtained for the energy region from 130 to 260 keV. The measurements indicate qualitatively that the conversion electrons in this energy region are emitted approximately 1 nsec after fission. The results favor attribution of E2 multipolarity to the low-energy γ radiation from fission. (auth)

**1087** PROTON EMITTERS AMONG Te ISOTOPES. Karnaukhov, V. A.; Ter-Akopyan, G. M.; Vertogradov, L. S.; Petrov, L. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Nucl. Phys., 6701A: No. 1, 23-32(1967).

The delayed proton emitters obtained by irradiating $^{92}$Mo with $^{20}$Ne and $^{22}$Ne ions and $^{94}$Mo with $^{20}$Ne ions were studied. Proton activities with half lives of 4.2 ± 0.2, 19 ± 0.7, 13 ± 2, and 60 to 80 sec were observed. The first two emitters are most likely to be Te isotopes with mass numbers 109 and 111, respectively. On the basis of the data obtained, the cross sections for the reactions $^{92}$Mo($^{20}$Ne,4−6n)$^{108-106}$Te were estimated. (auth)

**1088** THE BETA SPECTRUM OF $^{207}$Tl. Trischuk, J. M.; Kankeleit, E. (California Inst. of Tech., Pasadena). Contract AT(04-3)-63. Nucl. Phys., 6701A: No. 1, 33-40(1967). (CALT-63-28).

The shape of the beta spectrum of $^{207}$Tl decaying into the ground state of $^{207}$Pb was determined. The shape factor for this decay between doubly magic minus one nucleus is compared to recent single-particle model calculations. Differences from the theoretical predictions are explained in terms of core polarization. For this study two silicon solid-state detectors in 4π geometry were used. (auth)

**1089** CONVERSION ELECTRONS FROM (p,2n) AND (α,3n) REACTIONS ON VIBRATIONAL NUCLEI. Ejiri, Hiroyasu (Tokyo Univ.); Ishihara, Masayasu; Sakai, Mitsuo; Inamura, Takashi; Katori, Kenji. J. Phys. Soc. Jap., 21: 1021-31(June 1966).

The structure of excited states in neutron-deficient nuclei was investigated by observing conversion electrons from the (p,2n) and (α,3n) reactions on vibrational nuclei. Momentum spectra of the conversion electrons were measured by means of a sector-type beta spectrometer. Intensity ratios of the conversion electrons were analyzed in terms of the statistical model. The systematic trend of levels in the neutron deficient Te isotopes is discussed. The existence of a new deformed region is suggested between the neutron numbers N = 50 and N = 82. (auth)

**1090** OBSERVATION OF A SPONTANEOUSLY FISSIONABLE ISOMER WITH $T_{\frac{1}{2}}$ = 2.6 MIN IN THE NUCLEAR REACTIONS $^{233}$U + $^{11}$B AND $^{233}$U + $^{10}$B. Kuznetsov, V. I.; Skobelev, N. K.; Flerov, G. N. (Joint Inst. for Nuclear Research, Dubna, USSR). Yadern. Fiz., 4: 99-101(July 1966). (In Russian).

In the nuclear reactions $^{233}$U + $^{10}$B and $^{233}$U + $^{11}$B a spontaneously fissionable product with $T_{\frac{1}{2}}$ = 2.6 ± 0.2 min was observed. The excitation function of this product in the reaction $^{233}$U + $^{11}$B was investigated. The maximum production cross section was found to be of the order $2 \times 10^{-33}$ cm$^2$. The conclusion was drawn that the Am nucleus or that of another lighter element with mass number A ≤ 236 undergoes a spontaneous fission with $T_{\frac{1}{2}}$ = 2.6 min. The experiments were performed on the internal beam of the Y-300 cyclotron of the Joint Institute for Nuclear Research. (auth)

**1091** FISSIONABILITY OF NUCLEI IN THE REGION $Z^2/A > 35$ BY HIGH-ENERGY PROTONS. Konshin, V. A.; Matusevich, E. S.; Regushevskii, V. I. Yadern. Fiz., 4: 97-8(July 1966). (In Russian).

The cross sections for the fission of $^{237}$Np by 280- to 660-Mev protons and $^{239}$Pu by 660-Mev protons were measured. The $^{237}$Np fission cross section is equal to 1.52 ± 0.16 b for $E_p$ = 660 Mev and stays constant within the experimental errors in the proton energy region 280 to 660 Mev. The $^{239}$Pu fission cross section is equal to 1.80 ± 0.15 b at $E_p$ = 660 Mev. (auth)

**1092** NEUTRON-PROTON RATIO DETERMINATION IN THE PERIPHERY OF THE Xe NUCLEUS. Strugalski, Z. S. (Joint Inst. for Nuclear Research, Dubna, USSR). Nucl. Phys., 87: 280-8(1966).

From the analysis of $\pi^-$-Xe interactions at 9 Bev/c in the xenon bubble chamber, the neutron-proton ratio $N_n/N_p$ in the periphery of the Xe nucleus was determined. Within an accuracy of about 11%, the value of $N_n/N_p$ in the peripheral region of a nucleus is the same as in the whole nucleus. (auth)

**1093** KINETIC ENERGY AND CHARGE DISTRIBUTION OF THE FISSION FRAGMENTS. Lee, Tse-ching; Hwang, Sheng-nien; Zhu, Yei-zhung; Yue, Chwan-cha. Wu Li Hsueh Pao, 22: 245-9(Feb. 1966). (In Chinese).

The rapid decrease of the kinetic energy of the fragments after the fission was quantitatively examined, assuming that in nearly symmetric fission events the charge distribution $Z_p$ on the heavier fragment retains 50 full shells. The semi-empirical $Z_p$ function of Wahl and Seeger's nuclear mass formula were used to calculate the energy release in thermal-neutron induced fissions of $^{235}$U and $^{239}$Pu and the spontaneous fission of $^{252}$Cf, according to the relation: $E_f(Z_1A_1,Z_2A_2) = M(Z,A) - M(Z_1,A_1) - M(Z_2,A_2)$, where M(Z,A) represent the mass of the parent nucleus and the indices 1 and 2 indicate the daughter nuclei. The kinetic energy was estimated on the basis of time-of-flight data. An attempt was made to determine the energy removed from the system by the neutrons. (TTT)

**1094** ADVANCES IN THE FIELD OF NATURAL RADIOACTIVITY SINCE THE DISCOVERY OF URANIUM FISSION. Karlik, Berta (Oesterreichische Akademie der Wissenschaften, Vienna). Nukleonik, 8: 297-301(June 1966). (In German).

The natural radioisotopes discovered since 1939 are outlined with emphasis on the new types of nuclear transitions. 39 references. (J.S.R.)

**1095** DIRECTIONAL DISTRIBUTION OF ALPHA EMISSION IN $^{228}$Th DECAY SERIES. Biswas, M. M.; Gupta, B, K.; Sen, P. K.; Bhattacharya, P. C. (Calcutta Univ.). Z. Naturforsch., 21a: 902-5(July 1966).

Directionality of alpha emission in terms of alpha-alpha angular correlation distributions between the consecutive alpha particles in the serial decay of $^{228}$Th was experimentally studied from thorium stars produced in emulsion plate. The angular correlations fit a sin Θ distribution. (auth)

**1096** RATIOS OF ELECTROMAGNETIC TRANSITION PROBABILITIES IN LOW STATES OF ODD-A ROTATIONAL NUCLEI. Ashery, D.; Goldring, G. (Weizmann Inst. of Science, Rehovoth, Israel). Z. Naturforsch., 21a: 936-40(July 1966).

The systematics of M1 and E2 transition probabilities between low-lying states in odd-A rotational nuclei are reviewed. Some departures are found from strict rotational behavior in ratios of M1 and E2 transition probabilities in successive transitions. (auth)

**1097** ISOBARIC ANALOG STATES IN $^{145}$Eu. Marouchian, K.; von Brentano, P.; Wurm, J. P.; Zaidi, S. A. A. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 929-35(July 1966). (In German).

Excitation functions for the elastic proton scattering from the target nucleus $^{144}$Sm have been measured in the energy-range from 8.600 to 11.600 MeV at six different scattering angles. Strong resonances were observed in the highly excited compound nucleus $^{145}$Eu, which are the isobaric analogues to the low-lying states of $^{145}$Sm. The resonances have been interpreted as Breit-Wigner resonances, superimposed on a smoothly varying background. The analysis was carried out in terms of a single-level approximation. Energies, l-values, and widths of these resonances were determined, and are compared with corresponding results of (d,p) experiments. (auth)

**1098** MOESSBAUER INVESTIGATIONS ON THE $2^+$-ROTATION LEVELS OF $^{176}$Hf AND $^{180}$Hf. Gerdau, E.; Koerner, H. J.; Lerch, J.; Steiner, P. (Univ., Hamburg). Z. Naturforsch., 21a: 941-5(July 1966). (In German).

Mössbauer experiments have been performed on the 88.3-keV level in $^{176}$Hf and the 93.3-keV level in $^{180}$Hf. A model-independent ratio for the quadrupole moments of the $2^+$ rotational states could be derived from the measured hyperfine splittings. The result is $Q(^{176}Hf)/Q(^{180}Hf) = 1.10 \pm 0.02$, which is in agreement with the model-dependent value calculated from the transition probabilities. (auth)

**1099** EXPERIMENTAL EVIDENCE FOR ANOMALOUS L/M CONVERSION RATIO OF THE $2^+ \rightarrow 0^+$ TRANSITIONS IN SOME DEFORMED EVEN-EVEN NUCLEI. Bashandy, E.; Migahed, M. (Atomic Energy Establishment, Cairo). Z. Phys., 195: 435-43(1966).

The L-subshell and M conversion coefficients ratios of the $2^+ \rightarrow 0^+$ transitions in some deformed even-even nuclei were determined using a high-resolution iron-free double-focusing beta spectrometer. All possible uncertainties in these measurements were minimized and properly evaluated. The $L_1 + L_{11}/L_{111}$ ratios for the $2^+ \rightarrow 0^+$ E2 transitions in $^{160}$Dy, $^{166}$Er, $^{170}$Yb, $^{176}$Hf, and $^{182}$W are found to be in agreement with the theoretical ones within an experimental error of about 4%. However, large deviations from the theory of about two orders of magnitude are observed for L/M conversion ratios. The deviations indicate the possibility of considerable approximation in the theoretical calculation of the M-internal conversion coefficients. (auth)

**1100** MEASUREMENT OF THE $g_R$ FACTOR FOR THE $2^+$ ROTATIONAL STATE OF $^{172}$Yb BY THE MOESSBAUER METHOD. Muenck, E.; Quitmann, D.; Prange, H.; Huefner, S. (Technische Hochschule, Darmstadt, Ger.). Z. Naturforsch., 21a: 1318-19(Aug. 1966). (In German).

The magnetic hyperfine splittings of the 78.7-keV gamma ray of $^{172}$Yb and the 84.3-keV gamma ray of $^{170}$Yb were measured in $YbCl_3 \cdot 6H_2O$ using the Mössbauer technique with sources of Lu and $TmAl_2$. The following results were obtained: $g_R^{172} = 0.335 \pm 0.010$ and $g_R^{170}/g_R^{172} = 1.009 \pm 0.017$. (D.C.W.)

**1101** CHEMICAL EFFECT ON OUTER-SHELL INTERNAL CONVERSION IN $^{119}$Sn, INTERPRETATION OF THE MOESSBAUER ISOMER SHIFT IN TIN. Bocquet, J.-P. (Brookhaven National Lab., Upton, N. Y.); Chu, Y. Y.; Kistner, O. C.; Perlman, M. L.; Emery, G. T. Phys. Rev. Lett., 17: 809-13(Oct. 10, 1966).

With $^{119m}$Sn sources in two different chemical forms, high-resolution internal-conversion measurements were made of electron lines from the 23.87-keV M1 transition. It was found that the 5s (valence-shell) electron density near the nucleus is about 30% smaller in $SnO_2$ than in white tin; calculations show that roughly 17% of this decrease in 5s electron density is compensated for by an increase in the sum of 1s, 2s, 3s, and 4s densities. With this information on s electron densities and from the value of the Mössbauer chemical isomer shift between white tin and $SnO_2$, it is possible to conclude that the nuclear charge radius of the 23.87-keV state of $^{119}$Sn is $3.3 \times 10^{-4}$ larger than that of the ground state. (auth)

**1102** POLARIZATION OF THE NUCLEAR DIPOLE MOMENTS OF $^{135}$Ba AND $^{137}$Ba BY OPTICAL PUMPING. Olschewski, L.; Otten, E.-W. (Univ., Heidelberg). Z. Phys., 196: 77-84(1966). (In German).

The nuclear Zeeman levels of the ground state of Ba ($6s^2\ ^1S_0$, $F = I = 3/2$) were polarized by means of optical pumping with the resonance line ($6s^2\ ^1S_0 - 6s\,6p\ ^1P_1$, $\lambda = 5535$ Å). The magnetic field was calibrated by means of optical pumping of sodium. The magnetic moments, calculated from the nuclear Hf-Zeeman-transitions at 228 Gauss, are $\mu_{135} = 0{,}83651\ (6)\ \mu_N$ and $\mu_{137} = 0{,}93573\ (6)\ \mu_N$ (with diamagnetic correction). With the results of nuclear induction in $BaCl_2$ the chemical shift was calculated to be $(8.6 \pm 1.0) \cdot 10^{-4}$. The ratio of the nuclear moments is $\mu_{137}/\mu_{135} = 1.11862\ (3)$ in agreement with the measurements in $BaCl_2$. (auth)

**1103** THE CONVERSION ELECTRON SPECTRUM OF $^{198}$Au FOLLOWING THERMAL NEUTRON CAPTURE. Egidy, T. v.; Bieber, E.; Elze, Th. W. (Technische Hochschule, Munich). Z. Phys., 195: 489-504(1966). (In German).

The internal conversion electrons of $^{198}$Au following thermal-neutron capture in $^{197}$Au were measured with a beta spectrometer. 130 lines were found between 1 keV and 7 MeV. The multipolarities of 81 lines were determined. A level scheme with 10 levels containing most of the intense transitions is suggested. (auth)

**1104** THERMAL NEUTRON ACTIVATION CROSS SECTION OF $^{116}$Cd FOR THE PRODUCTION OF THE $^{117}$Cd ISOMERS. Decat, D.; Del Marmol, P. (Centre d'Etude de l'Energie Nucleaire, Mol, Belg.). Radiochim. Acta, 6: 29-31(Aug. 1966).

An isomeric cross section ratio $\sigma_m/\sigma_g = 0.54 \pm 0.10$ for the formation of 3.4-hr $^{117m}$Cd and 2.4-hr $^{117g}$Cd by the $^{116}$Cd$(n_{th},\gamma)$ reaction was measured by milking of the 1.92-hr $^{117m}$In and 39-min $^{117g}$In daughters. An activation cross section of $50 \pm 8$ mb was obtained for the $^{116}$Cd$(n_{th},\gamma)^{117g}$Cd reaction. (auth)

**1105** 14.8 MeV NEUTRON ACTIVATION CROSS SECTIONS FOR $^{181}$Ta$(n,\alpha)^{178m,g}$Lu AND $^{178}$Hf$(n,p)^{178m,g}$Lu. Meason, J. L.; Ganapathy, R.; Kuroda, P. K. (Univ. of Arkansas, Fayetteville). Contract AT(40-1)-3235. Radiochim. Acta, 6: 26-8(Aug. 1966).

Absolute neutron activation cross sections were measured for the production of 16- and 30-min $^{178}$Lu from $^{181}$Ta and $^{178}$Hf at a neutron energy of 14.8 MeV. The observed reactions and the corresponding cross sections are: $^{178}$Hf$(n,p)^{178}$Lu (16 min), $1.02 \pm 0.10$ mb; $^{178}$Hf$(n,p)^{178}$Lu (30 min), $1.72 \pm 0.17$ mb; $^{181}$Ta$(n,\alpha)^{178}$Lu (16 min), $0.14 \pm 0.04$ mb; and $^{181}$Ta$(n,\alpha)^{178}$Lu (30 min), $0.30 \pm 0.10$ mb. The existence of the 16- and 30-min half lives for $^{178}$Lu was confirmed. (auth)

**1106** STUDY OF BOUND NUCLEON WAVE FUNCTIONS BY COULOMB STRIPPING IN THE REACTION $^{208}$Pb(d,p)$^{209}$Pb. Dost, M.; Hering, W. R. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 1015-20(July 1966).

The differential cross sections of the $^{208}$Pb(d,p)$^{209}$Pb transitions to the states $9/2^+$, $5/2^+$, $1/2^+$, $1/2^+$, and $3/2^+$ in $^{209}$Pb were measured at 135° laboratory angle for deuteron energies between 7.0 and 10.5 MeV. The data below 8.0 MeV were analyzed in Coulomb wave Born approximation to give accurate spectroscopic factors of the five levels according to a simple shell model potential in the final nucleus. The dependence on some of the parameters that determine this potential is studied. The absolute value of the normalizing constants of the bound neutron wave functions outside the nuclear potential well is determined without reference to any shell model potential, i.e., their true values are given. It is confirmed that the ground and excited states up to 2.52 MeV in $^{209}$Pb are pure single particle states so that from their study one can draw a proper shell model potential in the lead region. (auth)

**1107** NUCLEAR REACTIONS BY DEUTERONS AT 52 Mev. Duelli, B.; Mairle, G.; Schmidt-Rohr, U.; Turek, P.; Wagner, G. (Kernforschungszentrum, Karlsruhe, Ger. Kernforschungsanlage, Juelich, Ger. Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Naturforsch., 21a: 969-76(July 1966). (In German).

The nuclear reactions of 52-MeV deuterons have been studied for some medium-weight and heavy nuclei. The angular distributions of elastically scattered deuterons show sharp structures which are smoothed out (similar to the results at lower deuteron energies) for target nuclei near A = 100. The optical-model analysis gives good fits with parameters extrapolated from the best values at lower energies. The smoothed cut-off models do not describe the results properly. The influence of the nuclear interior on the elastic scattering is important. The proton spectra from the (d,p) and (d,pn) reactions are dominated by a broad break up maximum. From the width of the maximum and the A-dependence of the cross section it is concluded that nuclear break up is more frequent at 52 MeV than Coulomb break up. The spectra of deuterons and tritons from the (d,d') and (d,t) reactions show maxima up to Q-values of −15 MeV. With these reactions it should be possible to study collective excitation up to high excitation energies and to get information about inner shells. The intensity of low-energy inelastic deuterons is surprisingly large. (auth)

**1108** REACTIONS (d,α) ON CADMIUM ISOTOPES. Kurchatov, B. V.; Rudenko, N. P.; Pastukhova, Z. V.

Vestn. Moskov. Univ., Ser. II: Khim., No. 6, 17-23(Nov.-Dec. 1965). (In Russian).

Nuclear reactions taking place on cadmium isotopes under the influence of 16-MeV deuterons were examined because that element possesses 6 even-neutron and 2 odd-neutron stable isotopes, making it possible to correlate the yield with the even-odd character of the nucleus. The experiments were carried out on the pure, natural mixture, determining the yield from the decay curves. Short-lived silver isotopes were also prepared. The results indicated that bombardment of cadmium with 8- to 16-MeV deuterons favors the (d,n) and (d,2n) reactions and, to a lesser extent, the (d,$\alpha$) reaction. The thresholds of all these reactions were close to 8 MeV. In the case of the (d,p) reaction, the threshold is shifted by about 2 MeV toward the lower energy range, indicating that the reaction probably follows the Oppenheimer-Phillips mechanism. (TTT)

**1109** REMOVAL OF ANGULAR MOMENTUM BY EVAPORATING NEUTRONS AND PHOTONS IN THE ($\alpha$,3n) REACTION. Shepherd, B. J.; Williamson, C. F.; Halpern, I. (Univ. of Washington, Seattle). Phys. Rev. Lett., 17: 806-8(Oct. 10, 1966).

Measurements of the relative intensities of ground-state rotational transitions which occur in deformed nuclei following ($\alpha$,3n) reactions are reported. An analysis of these intensities shows that the emissions (of neutrons and photons) which precede those in the ground-state band remove considerably more angular momentum from the emitting nuclei than one would estimate using a conventional statistical model. (auth)

**1110** FISSION OF HEAVY ELEMENTS INDUCED BY MEDIUM HIGH-ENERGY PROTONS. Pappas, Alexis C. (Univ. of Oslo). Z. Naturforsch., 21a: 995-1001(July 1966).

Fissionability, mass distribution, charge dispersion and distribution, and neutron emission for fission induced in heavy targets (uranium) by protons with a few hundred MeV kinetic energy are presented and phenomenologically discussed. The results are interpreted in order to arrive at the reaction mechanisms in medium-high energy induced fission. (auth)

**1111** RADIOCHEMICAL STUDIES OF FISSION INDUCED BY 14.7 Mev NEUTRONS. PART III. PROTACTINIUM. Brown, M. G.; Lyle, S. J.; Martin, G. R. (University Chemical Lab., Canterbury, Kent, Eng.). Radiochim. Acta, 6: 16-20(Aug. 1966).

A recoil method was used to measure the yields of 11 nuclides from the fission of $^{231}$Pa induced by 14.7 ± 0.2-MeV neutrons. In addition to the expected peaks corresponding to asymmetric fission yields, a third, lower peak occurred in the region of symmetric fission. The peak maxima fell at masses 92, 114, and 136 with absolute yields of 6.80 ± 0.36% and 2.48 ± 0.13% for asymmetric and essentially symmetric fission, respectively; yield minima occurred about mass 101 and 127. The peak widths at half-height are 14, 18.5, and 14 mass units. (auth)

**1112** THE RANGES OF FRAGMENTS IN THE FISSION OF $^{239}$Pu BY THERMAL NEUTRONS. Hollstein, M.; Muenzel, H. (Kernforschungszentrum, Karlsruhe, Ger.). Radiochim. Acta, 6: 9-15(Aug. 1966). (In German).

A method was developed to measure the ranges of fission products in aluminum in a "thick target–thick catcher" arrangement. The target consists of a dilute alloy of $^{239}$Pu in aluminum, the catcher of pure aluminum. The fragment ranges of $^{139}$Ba and $^{139}$Cs as well as the cumulative ranges of $^{139}$Ba, $^{139}$Cs, and $^{139}$Xe were determined. Results showed the fragment ranges $R_f$ within an isobaric chain are different. Their relative values normalized to the isobaric range $R_{is}$ are linearly dependent on the difference $Z-Z_p$: $R_f/R_{is} = 1.0-0.037\ (Z-Z_p)$. Assuming a constant-range dispersion for all members of an isobaric chain, the dispersion in the kinetic energy of primary fission fragments is about a factor of 0.5 smaller than previous values. (auth)

**1113** A SEARCH FOR GIANT RESONANCE BUILT ON ANALOGUE STATES. Allen, J. S.; Brussel, M. K.; Yavin, A. I. (Univ. of Illinois, Urbana). 15p. (CONF-660306–22). ORAU. Gmelin, AED-CONF-66-048-25.

From American Physical Society, Conference on Isobaric Spin, Tallahassee.

A search for photonuclear giant dipole resonances built upon particle unstable states was initiated. Proton beams between 21.85 and 23.0 MeV were used to bombard a target consisting of 99% $^{90}$Zr and 1% $^{91}$Zr. The reaction $^{90}$Zr(p,$\gamma$)$^{91*}$Nb was sought for by studying the possible proton decay of $^{91*}$Nb, where $^{91*}$Nb is the isobaric analog state of $^{91}$Zr. Evidence for a proton peak in the proton spectrum at 5.0 MeV was found. This peak remained essentially constant in energy as the beam energy was varied and appears to indicate that monoenergetic protons emerge from one of the following reactions: $^{90}$Zr(p,$\gamma$)$^{91*}$Nb, $^{90}$Zr(p,p')$^{90*}$Zr, $^{91}$Zr(p,n)$^{91*}$Nb. This suggests that the observation of monoenergetic proton groups may be a useful complement to ordinary techniques of nuclear spectroscopy. (auth)

**1114** ISOBARIC ANALOGUE STATES IN $^{131}$I. Burde, J.; Birstein, L.; Engler, G.; Ginsburg, A.; Jaffe, A. A.; Marinov, A. (Hebrew Univ., Jerusalem). 10p. (CONF-660306–18). ORAU. Gmelin, AED-CONF-66-048-23.

From American Physical Society, Conference on Isobaric Spin, Tallahassee.

The isobaric analog states of $^{131}$Te were investigated using proton elastic and inelastic scattering on $^{130}$Te. Excitation functions were measured over the energy range from 7.5 to 12.6 MeV. Spectra from two solid-state detectors were recorded simultaneously in multichannel analyzers. Absolute cross sections were also measured. (D.C.W.)

**1115** CALCULATION OF RESONANCE INTEGRALS FOR FISSILE MATERIALS. Adler, F. T.; Adler, D. B. (Univ. of Illinois, Urbana). 58p. (CONF-660204–23). ORAU.

From American Nuclear Society Meeting, San Diego, Calif.

The results obtained by numerical integration of the neutron balance equation are presented for various C–U mixtures in the neutron energy range from 2 to 30 eV. The role of overlap and interference effects is demonstrated by comparing results obtained with different assumptions for the cross sections of the fissile nuclides. The effects of the exact Doppler broadening are also considered. (D.C.W.)

**1116** RESONANCE CAPTURE CALCULATIONS FOR GAS-COOLED REACTORS. Tyror, J. G. (United Kingdom Atomic Energy Authority, Sellafield, Eng.); Beardwood, J. E.; Hart, A.; MacDougall, J. D. 26p. (CONF-660204–22; TRG-Report–1225). ORAU. Gmelin, AED-CONF-66-017-19.

From American Nuclear Society Meeting, San Diego, Calif.

A model of resonance capture that is used in the ARGOSY code for lattice calculations on graphite-moderated advanced gas-cooled reactors is described, and some results obtained with the ARGOSY code are compared with Monte Carlo calculations and with experimental results. (D.C.W.)

**1117** ANALOG STATES IN $^{94}$Mo STUDIES BY THE $^{93}$Nb(p,n)$^{93}$Mo REACTION. Finckh, E.; Jahnke, U.; Wirsich, J. (Hahn-Meitner-Institut fuer Kernforschung, Berlin). 7p. (CONF-660306–24). ORAU. Gmelin, AED-CONF-66-048-27.

From American Physical Society, Conference on Isobaric Spin, Tallahassee.

Analog states in the compound nucleus $^{94}$Mo were studied by the reaction $^{93}$Nb(p,n)$^{93}$Mo. Resonances were found at proton energies of 4.82, 4.86, 4.88, 4.90, 4.93, 5.14, and 5.16 MeV. Neutron lines to 14 levels in $^{93}$Mo were detected. (auth)

**1118** (p,n)-TOTAL CROSS SECTIONS ON $^{144}$Sm AND $^{142}$Nd. Messlinger, R.; Morinaga, H. (Max-Planck-Institut

fuer Kernphysik, Heidelberg). 7p. (CONF-660306-20). ORAU. Gmelin, AED-CONF-66-048-19).

From American Physical Society, Conference on Isobaric Spin, Tallahassee.

Excitation functions were determined for the reactions $^{144}Sm(p,n)^{144}Eu$ and $^{142}Nd(p,n)^{142}Pm$ for protons in the energy ranges 9.20 to 11.10 MeV and 9.35 to 10.35 MeV, respectively. The measurements were made by counting the positron activities of the product nuclei. The proton energy was varied in steps of 30 keV and, near resonances, in steps of 15 keV. Energy-level schemes are also given for the two reactions. (S.F.L.)

## Nuclear Theory

*Refer also to abstracts 596, 1079, and 1150.*

**1119** (AD-628823) TABLE OF SANIBEL (SPIN PROJECTION) COEFFICIENTS. Manne, Rolf (Uppsala Univ. (Sweden)). June 15, 1965. Contract AF61(052)-701. 64p. (ARL-66-0037). CFSTI $3.00 cy, $0.75 mn.

Projection coefficients for the total spin angular momentum of systems of 0 to 20 particles with spin $\frac{1}{2}$, calculated on a digital computer, are given in tabular form. (TAB)

**1120** (AD-634295) CHARGE STRUCTURE OF THE CALCIUM ISOTOPES. Gibson, B. F.; van Oostrum, K. J. (Stanford Univ., Calif.). May 1966. Contracts AF 49(638)-1389; Nonr-225(67). 39p. (ITP-215; HEPL-441). CFSTI $2.00 cy, $0.50 mn.

Phenomenological models of the ground-state charge densities of the calcium isotopes $^{40}Ca$, $^{44}Ca$, and $^{48}Ca$ exhibit both an increase in the half-radius which is less than one would expect from a simple $A^{0.33}$ estimate and an uneven variation in the skin thickness. A simple shell model of the nucleus with a Woods-Saxon potential is presented which can produce charge densities leading to electron scattering cross sections which agree with experiment as well as the phenomenological analyses. Strong closed-shell effects are found in the parameters describing the potential half-radius and skin thickness. (auth)

**1121** (AD-635915) THE N IN DEUTERON REACTIONS AS A LANDAU SINGULARITY. Month, Melvin (Illinois Univ., Urbana, Dept. of Physics). 1966. Contract Nonr-1834(05). 11p. CFSTI $1.00 cy, $0.50 mn.

Recently, some attempts have been made to describe what is termed the N effect in various deuteron reactions, using field-theoretical (perturbation theory) methods. Previously, the N peaks were introduced in a phenomenological way (i.e., as final-state interactions). It is pointed out, in a qualitative way, that a possible fallacy exists in the new approach (and in the phenomenological methods as well), and an alternative mechanism for producing the N effect is suggested. (TAB)

**1122** (AD-636033) THE MOESSBAUER EFFECT. Mukerji, Ambuj; Coulter, C. A. (Army Missile Command, Redstone Arsenal, Ala. Physical Sciences Lab.). Mar. 24, 1966. 48p. (AMC-RA-RR-TR-66-5). CFSTI $2.00 cy, $0.50 mn.

The theory of the nuclear Mössbauer effect and its optical analogue is presented. Introductory paragraphs deal with the destruction of resonance fluorescence in case of a freely recoiling nucleus. The partial restoration of resonance by Doppler effect and thermal broadening is outlined. The concept of zero-phonon transitions between bound nuclear states of nuclei embedded in a crystalline lattice is introduced in a simple quantum mechanical language. The classical derivation of the Debye-Waller factor based on the frequency modulation concept is followed by a rigorous quantum mechanical calculation of the zero-phonon transition probability and its temperature dependence. Lipkin's sum rule is discussed. Application of the Mössbauer effect to determine lifetimes of excited states, nuclear quadrupole moments, and the isomeric shifts is shown. The optical analogue in defect solids is described. (auth)

**1123** (JINR-P-2866) USLOVIE OPTIMAL'NOGO VYDELENIYA ROTATSIONNOI PEREMENNOI I MOMENT INERTSII YADRA. (Optimum Separability Condition for the Rotational Degree of Freedom and the Nuclear Moment of Inertia). Mikhailov, I. N.; Nadzhakov, E.; Safarov, R. Kh. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1966. 16p. Dep. mn.

The optimum separability condition for the rotational degree of freedom is used to determine the rotational spectra parameters of nuclei. An empirical formula which provides a very good numerical fit for the energies of states with $0 \leq I \leq 16$ is discussed. (auth)

**1124** (PUC-937-223) SIMPLE BRUECKNER-HARTREE-FOCK CALCULATIONS FOR LIGHT NUCLEI. Wong, Chun Wa (Princeton Univ., N. J.). July 1966. Contract AT(30-1)-937. 6p. (CONF-660906-34). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Conference on Nuclear Physics, Gatlinburg, Tenn.

The Hartree-Fock ground-state properties of $^{4}He$, $^{16}O$, and $^{40}Ca$ were calculated by using realistic nucleon-nucleon potentials. The reaction matrix elements were calculated accurately by the reference-spectrum method. The calculations give binding energies in rough agreement with the observed values, underestimating them by about 1 or 2 MeV per particle. However, the calculated equilibrium sizes are approximately correct. (auth)

**1125** (RLO-1388-10) HAUSER-FESHBACH ANALYSIS OF CROSS SECTIONS AND ANGULAR DISTRIBUTIONS FOR NEUTRON-INDUCED FISSION. Vandenbosch, R. (Washington Univ., Seattle). [1965]. Contract AT(45-1)-1725. 8p. (CONF-660906-31). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Conference on Nuclear Physics, Gatlinburg, Tenn.

An analysis was made of the apparent inconsistency between the rounded shape of the total fission cross section excitation function in the vicinity of the barrier and the rapid variation with energy of the anisotropy of the fragment distribution for $^{234}U$ and $^{236}U$ fission. The uniqueness of previous K-band assignments for these nuclei was also explored. It was concluded that no firm K-state assignments for neutron-induced fission of $^{234}U$ and $^{236}U$ can be made. Either $K = \frac{1}{2}^+$ or $K = \frac{1}{2}^-$, and probably both, states are present. A $\frac{3}{2}^+$ or $\frac{5}{2}^-$ state is involved in $^{236}U$. The subbarrier fission behavior and the rapidly varying anisotropies are explained in terms of a varying barrier curvature. (S.F.L.)

**1126** (UCRL-16843) PREDICTIONS OF NEW MAGIC REGIONS AND MASSES FOR SUPER HEAVY NUCLEI FROM CALCULATIONS WITH REALISTIC SHELL MODEL SINGLE PARTICLE HAMILTONIANS. Meldner, Heiner (Lawrence Radiation Lab., Univ. of California, Berkeley). Aug. 9, 1966. Contract W-7405-eng-48. 17p. (CONF-660817-6). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Symposium on Why and How Should we Investigate Nuclides Far Off the Stability Line, Lysekil, Sweden.

The single-particle part of a realistic shell model Hamiltonian is considered to contain a nonlocal potential similar to the classic Van Vleck nuclear potential. It was possible to get a consistent fit to (1) nuclear charge density distributions including isotope effects, (2) 1s proton levels as measured in (e,e'p) scattering, (3) total binding energies or nuclear mass defects, while (4) reproducing the shell model level sequences, i.e., spin assignments. Extrapolations to nuclei off the stability valley and to super heavy nuclei appear to be reasonable. In the latter case some evidence was found for a double magic nucleus at proton number 114 and neutron number 184 with a total binding energy around 2200 MeV. There is no indication of a double magic nucleus with $Z = 126$, $N = 184$ close to the line of $\beta$ stability. However, some support was found for a relatively long-lived compound

nucleus with these nucleon numbers by investigating metastable proton states. (auth)

**1127** CHARGE SYMMETRY AND THE ENERGY LEVELS IN LIGHT MIRROR NUCLEI. Fairbairn, W. M. (Univ. of Lancaster, Eng.). Nucl. Phys., 6701A: No. 1, 135-9(1967).

The differences in energies of the corresponding levels in mirror nuclei of the 1p shell are calculated. Coulomb forces, neutron-proton mass difference, and the electromagnetic spin-orbit forces are included in the calculation. Intermediate coupling is used, and the integrals involved are evaluated consistently for a physically reasonable value of the nuclear radius. No evidence is found for any breakdown of charge symmetry. (auth)

**1128** CHARGE STRUCTURE OF THE CALCIUM ISOTOPES. Gibson, B. F.; Van Oostrum, K. J. (Stanford Univ., Calif.). Contracts AF 49(638)-1389; Nonr 225(67). Nucl. Phys., 6701A: No. 1, 159-76(1967).

Phenomenological models of the ground-state charge densities of the calcium isotopes $^{40}Ca$, $^{44}Ca$, and $^{48}Ca$ exhibit both an increase in the half-radius which is less than one would expect from a simple $A^{\frac{1}{3}}$ estimate and an uneven variation in the skin thickness. A simple shell model of the nucleus with a Woods–Saxon potential which can produce charge densities leading to electron scattering cross sections which agree with experiment as well as the phenomenological analyses is presented. Strong closed-shell effects are found in the parameters describing the potential half-radius and skin thickness. (auth)

**1129** A DI-PROTON MODEL FOR THE (p,2p) REACTION. Jackson, Daphne F. (Univ. of Surrey, London). Nucl. Phys., 6701A: No. 1, 209-31(1967).

A treatment of the final state of the (p,2p) reaction is given in which the outgoing protons are regarded as a diproton. The model is developed using distorted-wave impulse approximation (DWIA). The validity of DWIA is discussed, and a prescription is given to obtain the best treatment of finite range effects within its framework. The di-proton model is used to discuss specific points such as localization of the reaction and the applicability of diffraction formulas, the effect of spin-orbit distortion, and the treatment of non-coplanar processes. (auth)

**1130** STRUCTURE OF FINITE NUCLEI AND THE FREE NUCLEON-NUCLEON INTERACTIONS. II. CORE POLARIZATION AND EFFECTIVE INTERACTIONS FOR THE NICKEL ISOTOPES. Kuo, T. T. S. (Princeton Univ., N. J.). Nucl. Phys., 6701A: No. 1, 199-208(1967). (PUC-937-207).

Using the reaction matrix theory, the effective interactions for the nickel isotopes are calculated from the Hamada–Johnston potential and are compared with the empirical values determined by Auerbach. The renormalization effects due to the core polarization are found to be very important. Impressive agreement is obtained. (auth)

**1131** VALIDITY OF THE NONRELATIVISTIC APPROXIMATION IN DISCUSSING BINDING BY LONG-RANGE POTENTIALS. Ram, Michael (Johns Hopkins Univ., Baltimore). Nucl. Phys., 87: 381-4(1966).

The validity of the nonrelativistic approximation in describing binding by long-range potentials is discussed. It is shown that for a long-range Yukawa potential the question of whether the problem is relativistic depends very much on the magnitude of the coupling constant. (auth)

**1132** EFFECTS OF NONLOCAL POTENTIALS. Srivastava, Y. N.; Weiss, M. S. (Northeastern Univ., Boston). Nucl. Phys., 6701A: No. 1, 140-4(1967).

The results of Austern on the Perey effect were rederived under more general assumptions for one dimension and are extended to three dimensions. A mechanism is proposed to explain the overestimation of calculated photonuclear cross sections. (auth)

**1133** SOFT CORE AND TWO-NUCLEON TENSOR FORCES. Lovitch, Lionel (Columbia Univ., New York); Rosati, Sergio. Nucl. Phys., 6701A: No. 1, 13-22(1967).

A detailed analysis of the deuteron state with soft square cores (i.e., finitely repulsive cores) is made to show in what sense a hard core may be considered to be the limit of a soft core. Sufficiency criteria are derived that determine whether a combination of central and tensor potentials is repulsive or attractive for any triplet state, and some numerical results are presented for potentials containing cores with both central and tensor parts. (auth)

**1134** TWO-QUANTUM TRANSITIONS OF ATOMIC NUCLEI: THE ($\gamma$,e) PROCESS. Grechukhin, D. P. Yadern. Fiz., 4: 42-51(July 1966). (In Russian).

Two-quantum ($\gamma$,e) processes are considered, in which the nuclear transition consists of the simultaneous emission of a $\gamma$ quantum and a shell conversion electron, and the nuclear transition energy is distributed continuously between these particles. Formulas are obtained for the probabilities of ($\gamma$,e) processes. (auth)

**1135** SUM RULES FOR REDUCED PROBABILITIES OF E2 TRANSITIONS IN NON-AXIAL EVEN-EVEN NUCLEI. Ovcharenko, V. I. (Inst. of Physics, Academy of Sciences, Ukrainian SSR). Yadern. Fiz., 4: 30-6(July 1966). (In Russian).

Previously known sum rules for the reduced probabilities of E2 transitions between states with spin 2 and 0 and states with spin 3 and 2 in a rigid nonaxial nucleus are generalized to the case of E2 transitions between states with arbitrary spins. It is shown that the sum of the reduced probabilities of E2 transitions between states with fixed initial and final spins, in a rigid nonaxial nucleus, does not depend on the nonaxiality parameter. (auth)

**1136** NEUTRON POTENTIALS FOR NUCLEI IN AN ISOTOPIC SEQUENCE. Sood, P. C. (Univ. of Alberta, Edmonton, Can.). Can. J. Phys., 44: 1719-22(Aug. 1966).

The shell model and the optical model potentials over wide ranges of nuclei can be represented satisfactorily as $V_0 \pm V_1 (N-Z)/A$, the plus sign corresponding to the proton potential and the minus to the neutron potential. The proton potentials for nuclei in an isotopic sequence agree with the above expression, but the corresponding neutron potentials are found to deviate. The deviations are attributed to the departures from the line of beta stability, and it is suggested that the neutron potentials for these cases should be represented by the expression $V_n = V_0 - V_1\{(N-Z)/A + (N-N_{st})/N_{st}\}$, $N_{st}$ being determined from the semiempirical mass formula. The results for Sn isotopes are cited to illustrate the phenomenon. (auth)

**1137** ON THE INFLUENCE OF THE PAULI PRINCIPLE ON ATOMIC NUCLEI. Hackenbroich, H. H.; Wahsweiler, H. G.; Wildermuth, K. (Univ., Tuebingen, Ger.). Z. Naturforsch., 21a: 870-80(July 1966).

The influence of the Pauli principle on some properties of nuclear systems consisting of a cluster surrounded by many other nucleons is discussed using two models. It is found that, though transition probabilities may be influenced drastically, the general features of the energetical behavior of such systems are practically unaffected by the exclusion principle. The consequences for real nuclei are discussed. For instance, closed shells remain energetically favored even if surrounded by many other nucleons. (auth)

**1138** DISTRIBUTION OF OCTUPOLE OSCILLATOR STRENGTH IN EVEN-EVEN SPHERICAL NUCLEI FROM Ni TO Pb. Veje, C. J. Kongel. Dan. Vidensk. Selsk., Mat.-Fys. Medd., 35: No. 1, 1-91(1966).

The distribution of the octupole oscillator strength, arising from one-phonon excitations of density variation modes in even-even spherical nuclei, is analyzed on the basis of an interaction consisting of pairing + octupole-octupole force. Special attention is given to the isospin structure of the states. It is found that, in many cases, two or three lines of comparable strength occur in the low-energy spectrum ($\lesssim$5 MeV). The experimental evidence on energy and transition probability, which is available almost only for the very lowest state, can be accounted for reasonably well by a strength constant for

the octupole-octupole force which varies smoothly with the atomic number. (auth)

**1139** INTERACTION OF COLLECTIVE DEGREES OF FREEDOM IN NUCLEI. Urbas, Tadas D.; Greiner, Walter (Univ., Frankfurt am Main). Z. Phys., 196: 44-52(1966).

The structure of the interaction of giant dipole and giant quadrupole oscillations with nuclear surface vibrations is established. The various coupling parameters are calculated in the hydrodynamic model. The significance of the interaction terms is discussed. (auth)

**1140** SYSTEMATICS OF SPALLATION YIELDS. Rudstam, G. (CERN, Geneva). Z. Naturforsch., 21a: 1027-41(July 1966).

Available experimental spallation data have been used to construct a five-parameter formula describing the cross-section distribution for a wide range of experimental conditions with a fair degree of accuracy. The application of the cross-section formula to different fields of research is indicated. (auth)

**1141** DOORWAY STATES AND INTERMEDIATE STRUCTURE PHENOMENA. Weidenmueller, Hans A. (Univ., Heidelberg). Z. Naturforsch., 21a: 896-901 (July 1966).

The phenomenon of the distribution of a doorway state over many complicated compound nuclear states, i.e., the formation and properties of a so-called micro-giant resonance, are investigated analytically and numerically by means of a simple model. The distribution of the poles in the complex plane and the distribution of the residues of the S matrix are obtained numerically and used to calculate the average cross-section. It is shown that the Lane-Thomas-Wigner theory applies, except for a possible correction to the shape of the resonance occurring in the cross-section averaged over the energy. This shape need not be describable by a Lorentzian. Estimates of the "spreading width" W and the "total width" $W_0$ are given for particular cases. It is noteworthy that the relationship $W_0 = W + \Gamma$ need not be correct even as an order-of-magnitude estimate, where $\Gamma$ is the decay width of the doorway state. (auth)

**1142** UNIFIED FORMULATION OF NUCLEAR FLUCTUATION THEORY. Boehning, M. (Univ., Heidelberg). Z. Naturforsch., 21a: 881-95(July 1966).

A formalism of nuclear fluctuation theory is developed which clarifies the general structure of nuclear fluctuation theory and allows one to predict the statistical properties of any kind of observable intensity from a nuclear reaction. The discussion is primarily concerned with purely fluctuating compound reactions. (S.F.L.)

**1143** FINE STRUCTURE OF THE ISOBARIC ANALOGUE RESONANCES. Mahaux, C. (Univ., Heidelberg). Z. Phys., 196: 240-54(1966).

The distribution of an isobaric analogue resonance over the numerous surrounding states of different isobaric spin is studied analytically in the frame of the Fano-Weidenmüller shell-model theory of nuclear reactions. The doorway state wave function is described by Lane's coupled equations. The matrix element of the residual nuclear interaction between this doorway state and a complicated state of different isobaric spin exhibits a particular energy dependence. A sum rule is established: the sum of the fine structure widths is larger than the width of the doorway state, as calculated from Lane's model. The residual Coulomb interactions are neglected. When perturbation theory holds, the distribution of the fine structure peaks is shown to have a characteristic asymmetrical shape. The connection with Robson's R-matrix treatment is discussed. (auth)

**1144** INTERNAL CONVERSION COEFFICIENTS FOR MAGNETIC MULTIPOLES FOR Z = 39. Bhalla, C. P. (Univ. of Alabama, Huntsville). Z. Phys., 196: 26-38 (1966).

Results of new internal conversion calculations for two values of gamma energy equal to 0.05 $mc^2$ and 0.15 $mc^2$ are presented and compared with earlier works of Rose, and Sliv and Band in the case of $^{87}Y$. Matrix-elements for the surface current model and the no-penetration model are presented. Differences were found between present calculations and the earlier works for k equal to 0.05 $mc^2$ and in particular for the K shell. It is suggested that these differences are partly due to the screening model used and possibly also due to the mesh-size employed. New calculations are based on the non-relativistic Hartree-Fock potential in the Slater exchange approximation. The earlier work was based on the Thomas-Fermi-Dirac model. Calculated eigenvalues agree extremely well with the experimental electron binding energies. A large number of points (2500) were used to minimize any errors due to mesh-size effects. (auth)

**1145** CHARGE DISTRIBUTIONS ACCORDING TO THE CLUSTER MODEL OF NUCLEAR FISSION. Faissner, H. (Technische Hochschule, Aachen). Z. Naturforsch., 21a: 1021-6(July 1966).

The cluster model of nuclear fission makes definite predictions about the charge distributions. The assumptions made in the computation of mass distributions have to be supplemented by the postulate of statistical sharing of the surplus protons and neutrons between light and heavy clusters. Given the mass distributions, the charge distributions are completely determined by statistical considerations. The calculated average charge $\langle Z_p \rangle$ as a function of fragment mass number $A_p$ for thermal-neutron-induced fission of $^{235}U$ agrees rather well with the radiochemical results and some recent mass-spectroscopic measurements. The shape of the charge distribution around $\langle Z_p \rangle$ depends on $A_p$, and is in fair agreement with the available data. (auth)

**1146** NONLOCAL POTENTIAL IN SINGLE-PARTICLE MODEL OF ATOMIC NUCLEI. Fischer, B. (Univ., Giessen, Ger.). Z. Phys., 196: 274-84(1966). (In German).

In the nonlocal part of the single-particle potential of bound nucleons, the Gaussian nonlocality, which was used in earlier papers, is replaced by a Yukawa potential and an exponential potential. The nonlocal parameters are fitted to the nucleon scattering experiments, and the results are used for a calculation of single-particle levels of $^{209}Pb$ and $^{201}Pb$. The nonlocality required by the Pauli exclusion principle is compared with the phenomenological approach. It turns out that the form of this nonlocality is essentially given by the supposed nucleon-nucleon potential. The range of this potential is determined by the experimentally known energy-dependence of the single-particle potential. (auth)

**1147** ISOBARIC SPIN TERM IN THE OPTICAL POTENTIAL. Drentje, A. G.; Van Wageningen, R. (Rijksuniversiteit, Groningen, Netherlands). Ned. Tijdschr. Natuur., 32: 87-94(Mar. 1966). (In Dutch).

The hole depth of the optical potential for neutrons and protons differs. Some possible explanations of this difference are described. A description of the effects is given with the help of the isobaric spin formalism and measurements of the effect are reviewed. (J.S.R.)

**1148** THE SURFACE DELTA INTERACTION IN DEFORMED NUCLEI. Faessler, Amand; Plastino, Angel; Moszkowski, Steven A. (Univ. of California, Los Angeles). 41p. (CONF-660411-59). ORAU. Gmelin, AED-CONF-66-060-134.

From American Physical Society Meeting, Washington, D. C.

The Surface Delta Interaction (SDI) is applied to deformed nuclei. For this purpose the equations of the quasi-particle random phase approximation for deformed nuclei are given. It is shown that the relations among the matrix elements of the SDI derived for spherical nuclei are also valid in the deformed case. The parameter of the SDI can be fixed by the odd-even mass differences, or it can be calculated using a self-consistency argument for the density and the shape of the potential. Comparing the matrix elements for the pairing plus quadrupole (or

octupole) force with the elements for the SDI, one is able to calculate the strength of the quadrupole and octupole forces from nuclear binding energies. The values so derived are in good agreement with the fits found in the literature for the quadrupole and the octupole parameters. (auth)

**1149** FORMULA FOR THE (n,2n) CROSS SECTION BASED ON THE COMPOSITE DESCRIPTION OF NUCLEAR LEVEL DENSITIES. Carter, H. G.; Williams, J. R. (General Dynamics, Fort Worth, Tex.). 14p. (CONF-660606-23). ORAU. Gmelin, AED-CONF-66-203-56.

From American Nuclear Society Meeting, Denver, Colo.

The form of the level-density law for the calculation of (n,2n) cross sections is discussed, and the results of some calculations using a composite-model cross-section formula are presented and are compared with other predictions and with experimental observations. (D.C.W.)

**1150** THEORY OF ISOBARIC SPIN ANALOGUE RESONANCES. Stephen, R. O. (Washington Univ., Seattle). 34p. (CONF-660306-21). ORAU. Gmelin, AED-CONF-66-048-21).

From American Physical Society, Conference on Isobaric Spin, Tallahassee.

A theory of isobaric analog resonances is presented and expressions for the resonant and nonresonant parts of the T-matrix are given. Expressions for the total width and partial proton width of a pure analog state are also given. The effect of Coulomb configuration mixing is studied with emphasis on the effect of mixing on the profile of an observed analog resonance. (D.C.W.)

**1151** COLLECTIVE TREATMENT OF THE GIANT RESONANCES IN SPHERICAL NUCLEI. Huber, M. G.; (National Bureau of Standards, Washington, D. C.); Danos, M.; Weber, H. J.; Greiner, W. 69p. (CONF-660411-53). ORAU. Gmelin, AED-CONF-66-060-128.

From American Physical Society Meeting, Washington, D. C.

In a collective treatment the energies of the giant resonances are given by the boundary conditions at the nuclear surface which is subject to vibration in spherical nuclei. The general form of the coupling between these two collective motions is given by angular-momentum and parity conservation. The coupling constants are completely determined within the hydrodynamical model. In the present treatment the influence of the surface vibrations on the total photon absorption cross section is calculated. It turns out that in most of the spherical nuclei this interaction leads to a pronounced structure in the cross section. The agreement with the experiments in medium heavy nuclei is striking; many of the experimental characteristics are reproduced by the present calculations. In some nuclei, however, there are indications of single-particle excitations which are not yet contained in this work. (auth)

# REACTOR TECHNOLOGY

## Central Power Reactors

*Refer also to abstracts 358, 500, 502, 1153, 1166, 1169, 1178, 1180, 1182, and 1183.*

**1152** (ACNP–65599) PATHFINDER ATOMIC POWER PLANT. BOILER CORE AND FULL CORE CRITICAL EXPERIMENTS. Lacy, P. S.; Kern, R. C.; Lewellen, J. W.; Smith, J. A. (Allis-Chalmers Mfg. Co., Bethesda, Md. Atomic Energy Div.). Aug. 31, 1966. Contract AT(11-1)-589. 79p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

For Northern States Power Co., Minneapolis, Minn. and Central Utilities Atomic Power Associates.

Three major tests were performed on the Pathfinder core: boiler core loading and criticality, full core loading and criticality, and reference core loading and criticality. Core refueling was done between the full core and reference core tests. The Pathfinder core, the analytical model used to calculate neutron multiplication characteristics, and experimental procedures and results for the tests are described. (H.D.R.)

**1153** (ACNP–66557) ELK RIVER REACTOR OPERATIONS ANALYSIS PROGRAM. Annual Progress Report, July 1, 1965–June 30, 1966. Fisher, J. R.; Kendrick, E. D.; Kruzic, T. P.; Schafer, A. C. Jr. (Allis-Chalmers Mfg. Co., Bethesda, Md. Atomic Energy Div.). Contract AT(11-1)-1357. 122p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

The operating history of the Elk River reactor is summarized for the reporting period. Investigations of core nuclear characteristics included reactivity, control rod worth, and power distribution measurements. Fuel cycle studies were performed to establish a fuel loading pattern for Core II, and nuclear characteristics of the final loading pattern are included. Proposed changes in the technical specifications describing the use of Core II fuel elements and $B_4C$ in-tube-type control rods are discussed. Plant energy transfer system performance was analyzed, and corrosion samples inserted into the evaporators in June 1964 were removed and examined. Analyses of the need for the addition of more capacity for collecting primary system condensate and of modifications to improve operational control of the control rod thimble cooling system are presented. Criticality calculations were performed for the 28-element spent fuel shipping cask to ensure that the cask would meet requirements. (H.D.R.)

**1154** (AE–244) PHYSICS EXPERIMENTS AT THE AGESTA POWER STATION. Apelqvist, G.; Bliselius, P.-A.; Blomberg, P. E.; Jonsson, E.; Akerhielm, F. (Aktiebolaget Atomenergi, Stockholm (Sweden)). Sept. 1966. 31p. Dep. mn.

Dynamic measurements were performed at the Ågesta reactor at power levels from 0.3 to 65 MW(t). The purposes of the experiments were both to develop experimental methods and equipment for the dynamic studies and to measure the dynamic characteristics of the reactor in order to check the dynamic model. The experiments were performed with four different perturbation functions: trapezoidal and step functions and two types of periodic multifrequency signals. Perturbations were introduced in the reactivity and in the load. Recordings were made of the responses of nuclear power, coolant inlet and outlet temperature and control rod position. The results are presented as step responses and transfer functions (Bode diagrams), and show good agreement with the results obtained from a dynamic model. Experience on reactor noise analysis based on measurements in the Ågesta power reactor is discussed. Static measurements of the physics parameters in the Ågesta reactor were carried out to confirm theoretical methods for reactor calculations and to form a good basis for safe operation of the reactor. The reactivity worth of groups of control rods was determined with different methods and compared with calculations with the three-dimensional code HETERO. The excess reactivity as a function of burnup is obtained from the control rod positions. The temperature coefficient of the moderator was measured by lowering the moderator temperature at constant power and observing the change in control rod insertion. The xenon poisoning effects were measured by changing the power level and studying the subsequent control rod insertions as a function of time. The effect on the reactivity due to changes of the pD value of the moderator was measured and found to be small. The radial power distribution was found both from the coolant temperature rise in the individual fuel channels and from an out-of-pile $\gamma$-scanning of representative fuel elements. The burnup distribution was also calculated with HETERO. Flux fine-structure in burned fuel was measured by irradiating spectrum-sensitive foils. (auth)

**1155** (AECL–2608) THE EXAMINATION OF DEFECTED NPD FUEL BUNDLE 0992. Report No. 611-2,093441-6. Popple, R. T.; Chalder, G. H. (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Aug. 1966. 16p. (EXP-NPD–205). Dep. mn. AECL $0.50.

An NPD fuel bundle removed from the reactor in a defected condition was examined. The defect was found to be in the form of an asymmetric gouge removed from the end cap-sheath weld zone of one element, opening a hole to the fuel. It is concluded that this defect was caused by contact with a latch in the coolant channel during a reverse fueling. The bundle operated in a defected condition for 28 months without significant deterioration. (auth)

**1156** (BNWL–CC–700) THE COMBINATION OF ON-LINE ANALYSIS WITH COLLECTION OF MULTICOMPONENT SPECTRA IN A PDP-7. Wilburn, N. P.; Coffin, L. D. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). July 15, 1966. Contract AT(45-1)-1830. 174p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

A small digital computer has been interfaced to four 256-channel analyzers. All functions of normal multichannel analyzers were reproduced by suitable coding. In addition, a weighted least-squares method for estimating on-line the contribution of individual radionuclides in a multicomponent pulse height spectrum has been incorporated. Details of the mathematics and coding methods used, which include special modifications to the existing FORTRAN system for on-line use, are described. (auth)

**1157** (CONF-661001–26) NUKER: A PROGRAM FOR THERMAL AND MECHANICAL ANALYSIS OF FUEL RODS. Moyar, G. J.; Koenig, E. F.; Leichliter, G. L.; Anderson, W. K. (Knolls Atomic Power Lab., Schenectady, N. Y.). Aug. 1966. Contract W-31-109-eng-52. 30p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From 14th Conference on Remote Systems and Technology, Pittsburgh, Pa.

NUKER can be used for rapid, broad parameter studies leading to a preliminary design selection. Once this selection has been made, more sophisticated methods of analysis should be chosen and the fuel selection verified by complete study of its behavior over the expected lifetime of the plant. Subsequent proof of the results of these analyses by properly designed irradiation tests may be necessary if, in any area of the design, the performance requirements go beyond existing proven performance of materials or design. (auth)

**1158** (EURAEC–1683) ANNUAL REPORT OF THE RESEARCH PROGRAM ON THE HEAT TRANSFER AND FLUID FLOW CHARACTERISTICS OF A PRESSURIZED WATER REACTOR, JANUARY 1964–JANUARY 1965. Spigt, C. L.; Boot, P. G. M. (Technische Hogeschool, Eindhoven (Netherlands)). July 1966. Contract 011-64-1-Teen (R. D.). 38p. (WW–015–R-109; EUR–2870). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

The 140-atmospheres pressurized water loop, the power supply, and the measuring, recording and analyzing equipment are described, and an outline is given of the theoretical and experimental research program. The activities were mainly directed toward getting the pressurized water loop in operation. At the end of the first year, the operational behavior from the point of view of water characteristics, scaling of the heating elements, and adjustment of stable conditions was very satisfying. The loop was in such a condition that the experimental program proposed could be started. A start was also made on a physical-mathematical description of the flow process occurring in a multirod fuel assembly incorporating the transverse transport of fluid coming from diffusion and radial pressure differences. (auth)

**1159** (GA–7149) HIGH-TEMPERATURE GAS-COOLED ADVANCED CONVERTER REACTORS AND THE COLORADO PROJECT. Jaye, S.; Rickard, C. L.; Stewart, H. B. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). May 16, 1966. Contracts AT(04-3)-633; AT(04-3)-167. 37p. (CONF-660554–1). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From Symposium on High Temperature Reactors and the Dragon Project, London, England.

The design objectives and anticipated fuel cycle performance characteristics of commercial HTGR power plants in the 660 MW(e) and 1000 MW(e) sizes are discussed. Design considerations that have evolved in the 330 MW(e) prototype being developed for the Public Service Company of Colorado are also described. (H.D.R.)

**1160** (GA–7162) PRESTRESSED CONCRETE PRESSURE VESSELS FOR POWER REACTORS. Rockenhauser, W. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). June 8, 1966. Contracts AT(04-3)-167; AT(04-3)-633. 15p. (CONF-660429–10). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From American Power Conference, 28th Annual Meeting, Chicago.

The design concept of prestressed concrete pressure vessels (PCRV) is described. The advantages of PCRV are absence of size limitations and safety due to structural redundancy. Development work on PCRV's in Europe and U. S. is reviewed. (D.L.C.)

**1161** (GAMD–6924) NONLINEAR ANALYSES OF XENON STABILITY IN HIGH TEMPERATURE GAS-COOLED REACTORS. Dahlberg, R. C.; Mangan, D. (General Dynamics Corp., San Diego, Calif. General Atomic Div.). Jan. 26, 1966. Contract AT(04-3)-167. 24p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Results are presented for nonlinear xenon stability analyses in a 1000 MW(e) HTGR and the effect of fuel zoning on the axial stability of a 330 MW(e) HTGR. Calculations were performed with GAZED, a one-dimensional depletion program. The sensitivity of the instability to core size and power density and the effect of power coefficient feedback on the instability are examined. Axial zoning of the type considered for some advanced HTGR designs is also considered. (H.D.R.)

**1162** (GEAP–5175) EVESR NUCLEAR SUPERHEAT FUEL DEVELOPMENT PROJECT. Sixteenth Quarterly Report, March–May 1966. Roof, R. R. (General Electric Co., San Jose, Calif. Advanced Products Operation). June 1966. Contract AT(04-3)-189. 168p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

The plant was available during all but 10 days of the quarter, accounting for a plant availability of 89%. Reactor power levels of up to 15 MW(t) were maintained with both intentional and in-service defects in the core. During the planned EVESR shutdown during the first part of March, Mark III fuel bundle KB-41 containing 0.450-in.-dia superheat fuel rods with 0.008-in.-thick Incoloy-800 cladding was reinstalled in the reactor for further irradiation. A purposely defected fuel rod containing a slot through the cladding was included in Mark III fuel bundle KB-41 to study the mechanism of fuel failure propagation. After reaching a power level of 15 MW(t), a significant increase in the turbine condenser off-gas radioactivity was observed. The radioactivity was determined to be coming from Mark III fuel bundle KB-40 which contains fuel rods having 0.012-in.-thick Incoloy-800 cladding. It was decided to remove KB-40 from the reactor immediately for examination. The fuel rod cluster containing the defect was located, removed, and a new cluster was installed in its place. Mark III fuel burnup of 5900 MWd/t-U (axial peak) was attained by the end of the report period. The Mark V fuel mechanical design and development were completed. All materials for four bundles of Mark V fuel have been ordered and most have been received. Fabrication is approximately 75% complete. Post-irradiation examination of the following superheat materials was initiated: Mark II fuel bundle KB-11 containing Incoloy-800 clad annular-type fuel, Mark III fuel bundle KB-40, and cladding materials burst and tensile test specimens which were irradiated in GETR. Physics and thermal-hydraulic analyses for operation at higher specific power and for irradiation of Mark V fuel in EVESR were essentially completed. (H.D.R.)

**1163** (GEAP–5190) DEVELOPMENT PROGRAM ON THE GARIGLIANO NUCLEAR REACTOR. Quarterly Report No. 15. Howard, C. L. (General Electric Co., San Jose, Calif. Atomic Power Equipment Dept.). July 1, 1966. Contract AT(04-3)-189. 35p. (EURAEC–1717). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Work Performed Under United States–Euratom Joint Research and Development Program.

Four instrumented fuel assemblies and three moveable ion chambers were installed in the reactor and provided data on channel flow rates, water inlet and outlet temperatures, and neutron flux during the stability tests. Measurements of gross reactor power distribution by gamma scan of the irradiated fuel were analyzed and found to be in good agreement with calculations of the on-line computer. Results of rod oscillator test runs are presented. Preliminary analysis indicates that the reactor is more stable than predicted at core average voids (in channels) as high as 50%. (H.D.R.)

**1164** (IDO-17210) SEFOR $\beta/\ell$ MEASUREMENTS BY NOISE ANALYSIS TECHNIQUES. Morrell, R. P. (Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div.) Aug. 1966. Contract AT(10-1)-205. 50p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Cross-power spectrum techniques as applied to $\beta/\ell$ measurements on the ZPR-III mockup of the SEFOR core are evaluated. Methods used to obtain the auto-power spectra and cross-power spectrum of two signals contaminated with noise are reviewed. Summaries are presented of the problems of obtaining a reactor cross-power spectrum using two detectors, of the frequency response determination of the chambers and the associated amplifiers and tape recording equipment, and of the results of the measurement and evaluation of $B/\ell$ in the SEFOR ZPR-III. (H.D.R.)

**1165** (JUL–350-VW) REAKTORDRUCKGEFAESSE AUS SPANNBETON. KURZER ABRISS DES HEUTIGEN ENTWICKLUNGSSTANDES. (Reactor Pressure Vessels from Stressed Concrete. Short Summary of the Present State of Development). Luks, Harald (Kernforschungsanlage, Juelich (West Germany)). July 1966. 39p. Dep. mn.

A review is given of the use of prestressed concrete pressure vessels. The function of a pressure vessel is summarized and the differing requirements in different reactor types are indicated. The technical and engineering problems connected with the use of stressed concrete are not studied, but only indicated. (J.S.R.)

**1166** (NAA-SR–11378(Vol.2)) FEASIBILITY STUDY OF A 1000-Mwe SODIUM-COOLED FAST REACTOR. (Atomics International, Canoga Park, Calif.). July 1966. Contract AT-11-1-GEN-8. 68p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Program needs are delineated for the development of fast reactor technology to the point where 200 to 300 MW(e) prototype can be built and operated. Overall requirements are presented for concept development, safety and physics, mechanical equipment development and tests, sodium components and technology, fuel element technology, and fast test reactors. (H.D.R.)

**1167** (NAA-SR-Memo-9758) PRESENTATION ON SODIUM GRAPHITE REACTOR PROTOTYPE [AT] ATOMIC ENERGY COMMISSION, GERMANTOWN, MARYLAND, MARCH 20, 1964. Wensch, G. W.; Siegel, Sidney (Atomics International, Canoga Park, Calif.). Contract AT(11-1)-Gen-8. 37p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The objectives of a program to develop the sodium graphite reactor concept for large central station power plant applications are summarized. The status of the plant design and technology is reviewed, and operating experience with the Hallam reactor and the Sodium Reactor Experiment is discussed. (H.D.R.)

**1168** (NAA-SR-Memo-10123) CARBURIZATION POTENTIAL DETERMINATION FOR HNPF HOT TRAP SODIUM SAMPLES NOS. 18, 19, AND 20. Stearns, J. D. (Atomics International, Canoga Park, Calif.). June 24, 1964. Contract AT(11-1)-Gen-8. 14p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Sodium samples and Type 304 stainless steel tabs taken from the HNPF hot trap have been subjected to both chemical and metallurgical analyses to determine the C content of the Na. Although considerable scatter in results was observed, most determinations indicated that the C levels were only a few ppm above the equilibrium value (with 304 stainless steel) at 1200°F (18 ppm C in Na). No evidence of increased carburization potential from moderator can failures was observed. (auth)

**1169** (NAA-SR-Memo-12071) PIQUA NUCLEAR POWER FACILITY REACTOR OPERATIONS ANALYSIS PROGRAM. Report No. 41, January-April 1966. DeBear, W. S.; Fukushima, T.; Hansen, A. I.; Perret, J. D. Jr.; Roecker, J.; Shepard, R. C.; Tondi, D. (Atomics International, Canoga Park, Calif.). July 1966. Contract AT-11-1-GEN-8. 53p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

The reactor operation is summarized for January 1–13, 1966. On January 13 the reactor scrammed because of a faulty level switch on the degasifier tank and has remained shutdown since that time. The core nuclear behavior, temperature surveillance, main heat transfer system performance, and in-core filter performance are discussed. Core examination and analysis activities included investigations of control rod binding, fuel element removal and examination, and studies of carbonaceous growth in the outer moderator region. Core modification studies were initiated to improve the outer moderator flow conditions and eliminate the formation of the carbonaceous deposits. Coolant quality and in-core deposits analyses are tabulated. (H.D.R.)

**1170** (ORNL-NSIC-19) INDEXED BIBLIOGRAPHY OF CURRENT NUCLEAR SAFETY LITERATURE-6. (Oak Ridge National Lab., Tenn.). Sept. 1966. Contract W-7405-eng-26. 198p. Dep. mn. CFSTI $6.00 cy, $1.25 mn.

The sixth bibliographic compilation prepared by the Nuclear Safety Information Center is presented. The items are sorted into 19 categories of nuclear safety information and subject and author indexes are included. (H.D.R.)

**1171** (ORNL-P-2405) PERFORMANCE OF FILTER SYSTEMS UNDER ACCIDENT CONDITIONS. Adams, R. E.; Gill, J. S.; Yuille, W. D.; Browning, W. E. Jr.; Parsly, L. F.; Guthrie, C. E. (Oak Ridge National Lab., Tenn.). [1964]. Contract W-7405-eng-26. 29p. (CONF-660904-8). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From 9th Air Cleaning Conference, Boston, Mass.

The effectiveness of various gas cleaning media and systems for removing particulate dispersions expected in accidents to reactors of various types is investigated under simulated accident conditions. Laboratory work included the development of a single method for generating a simulant aerosol, tests of these aerosols to determine their validity as simulants, and measurements of the efficiency of absolute filter media for removing these simulant aerosols. Four large-scale filter tests were conducted in conjunction with experimental runs at the Nuclear Safety Pilot Plant. (H.D.R.)

**1172** (ORNL-TM-733(Rev.2)) MSRE DESIGN AND OPERATIONS REPORT. PART VI. OPERATING SAFETY LIMITS FOR THE MOLTEN-SALT REACTOR EXPERIMENT. Beall, S. E.; Guymon, R. H. (Oak Ridge National Lab., Tenn.). Sept. 19, 1966. Contract W-7405-eng-26. 6p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Limits are specified for various parameters relating to the containment, fuel system, coolant system, control rods, nuclear control and safety instrumentation, and personnel radiation monitoring for operation of the MSRE. (H.D.R.)

**1173** (ORNL-TM-1626) PERIOD MEASUREMENTS ON THE MOLTEN SALT REACTOR EXPERIMENT DURING FUEL CIRCULATION: THEORY AND EXPERIMENT. Prince, B. E. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 35p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

As an aid in interpreting the zero-power kinetics experiments performed on the MSRE, a theory of period dependence on the fuel circulation is developed from the general space dependent reactor kinetics equations. A procedure for evaluating the resulting inhour-type equation by machine computation is presented, together with numerical results relating the reactivity to the observed asymptotic period, both with the fuel circulating and with it stationary. Based on this analysis, the calculated reactivity difference between the time independent flux conditions for the noncirculating and the circulating fuel states is in close agreement with the value inferred from the MSRE rod calibration experiments. Rod-bump period measurements made with the fuel circulating were converted to differential rod worth by use of this model. These results are compared with similar rod sensitivity measurements made with the fuel stationary. The rod sensitivities measured under these two conditions agree favorably, within the limits of precision of the period measurements. Due to the problem of maintaining adequate precision, however, the period-rod sensitivity measurements provide a less conclusive test of the theoretical model than the reactivity difference between the time independent flux conditions. Suggestions are made for improving the precision of the experiments to provide a more rigid test of the theoretical model for the effects of circulation on the delayed neutron kinetics. (auth)

**1174** (STI-DOC-10/56) PRESSURE VESSEL CODES: THEIR APPLICATION TO NUCLEAR REACTOR SYSTEMS. Findings from a Survey. Technical Reports Series No. 56. (International Atomic Energy Agency, Vienna (Austria)). May 1966. 36p. IAEA: $1.00; S 21,-; 6/-stg; F Fr 4,-; DM 3,20.

A survey was made of how national pressure vessel codes have been applied to pressurized reactors in IAEA member states. Fifteen answers to inquiries were received, and information based on the answers is presented. The limitations of the codes are discussed. (D.L.C.)

**1175** (SwRI-1228-65) CONSULTING REPORT ON THE INSPECTION OF EXPERIMENTAL BOILING WATER REACTOR PRESSURE VESSEL. Wylie, Robert D. (Southwest Research Inst., San Antonio, Tex.). June 18, 1965. Contract AT(11-1)-1228. 18p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

An inspection of the EBWR revealed a series of cracks on the surface of the stainless steel resistance cladding of the pressure vessel. Details are presented on the metallurgical examination of strips of stainless steel and both samples of carbon steel and stainless steel removed from the vessel. (H.D.R.)

**1176** (TID-23352) QUARTERLY REPORT NO. 16, APRIL 1–JUNE 30, 1966. (Societe d'Energie Nucleaire

Franco-Belge des Ardennes, Chooz-Lez-Givet (France)). Aug. 4, 1966. 16p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Summaries are presented on design studies, prefabricated components, and on-site work at the Ardennes nuclear power plant. (H.D.R.)

**1177** (TID-23356) [PATHFINDER ATOMIC POWER] PLANT OPERATING EXPERIENCE UP TO 5MWT. Phase II Report. (Northern States Power Co., Sioux Falls, S. Dak.). [1966]. Contract AT(11-1)-589. 43p. (NSP-6602). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The reactor core performance, plant equipment performance, radiation protection studies, and reactor water chemistry studies are summarized for Phase II of the Power Operation Test Program. (H.D.R.)

**1178** (WAPD-MRP-117) PRESSURIZED WATER REACTOR (PWR) PROJECT. Technical Progress Report, April 23, 1966-July 22, 1966. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Contract AT-11-1-GEN-14. 129p. Dep. mn. CFSTI $4.00 cy, $1.00 mn.

Progress at the PWR project is reported in the areas of PWR plant support, reactor mechanical design, reactor thermal design, reactor physics, fuel element development, and PWR core engineering. (J.R.D.)

**1179** (WAPD-PWR-2210(Vol.2)) NUCLEAR PROTECTION SYSTEM. Instruction Book. (General Dynamics/Electronics, Rochester, N. Y.). Oct. 1, 1963. Contract AT-11-1-GEN-14. 635p. Dep. mn. CFSTI $9.35 cy, $2.50 mn.

For Westinghouse Electric Corp., Pittsburgh, Pa. Atomic Power Div.

A series of instruction manuals for components of the Shippingport reactor nuclear protection system are included. Installation, operation, and maintenance procedures are given, and circuit diagrams and drawings are presented. (H.D.R.)

**1180** (WCAP-3589-2) PERFORMANCE CHARACTERISTICS OF A LARGE FAST BREEDER REACTOR CORE WITH BUNDLE CONTROLLED EXPANSION (BCEX) FUEL ASSEMBLIES. (Westinghouse Electric Corp., Pittsburgh, Pa. Atomic Power Div.). May 1966. Contract AT(30-1)-3589. 474p. Dep. mn. CFSTI $7.74 cy, $2.00 mn.

Included are the identification of the problem areas, and the analyses and evaluation of the performance characteristics of the Bundle Controlled Expansion (BCEX) concept in the Westinghouse Large Fast Breeder Reactor using a modular, carbide-fueled core. The dynamic behavior of a second concept, fuel rod Clad Controlled Expansion (CCEX) was also studied briefly in the carbide-fueled modular core. The dynamic performance of the BCEX and CCEX concepts were also briefly investigated in a gas bonded, oxide-fueled core. The results of all the transient analyses performed in this investigation demonstrated that utilization of either of the axial thermal expansion concepts, CCEX or BCEX, significantly improved the core transient behavior over that of the non-CEX (zero thermal expansion) core. Both BCEX and CCEX can potentially provide ceramic-fueled fast reactor cores with a predictable, negative, axial expansion, reactivity feedback mechanism that will contribute significantly in terminating a power excursion by supplementing the Doppler coefficient. (auth)

**1181** (WCAP-6081) YANKEE CORE EVALUATION PROGRAM QUARTERLY PROGRESS REPORT FOR THE PERIOD ENDING JUNE 30, 1966. O'Boyle, M. J. (comp. and ed.) (Westinghouse Electric Corp., Pittsburgh, Pa. Atomic Power Div.). Aug. 1966. Contract AT(30-1)-3017. 76p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

Tensile strength and microhardness measurements were completed for all scheduled Phase III cladding specimens. These measurements were consistent with those from Phase I (14 Core I assemblies) and Phase II (a Core I assembly recycled in Core II for extended burnup), and they further illustrated the tendency for radiation-induced changes in mechanical properties to saturate out after exposures equivalent to one core life. The data from isotopic analyses and from radiochemical analyses were processed to establish the average burnup of the Phase III fuel assembly, and the average burnup of each of the eight fuel rods that were removed from this assembly and destructively analyzed. Flux wire and thermocouple data from Yankee Core IV were processed to establish the power history of the recycled Phase III assembly during Core IV operation. The Phase III fuel assembly was cycled in Core I, recycled in Core II for extended burnup, and recycled again in Core IV where it achieved a peak burnup of 46,000 MWd/MTU. Selected pieces of Yankee cladding were packaged and shipped to General Electric for study. Work commenced on design and procurement of the containers in which the remaining pieces of examined Yankee fuel rods will be shipped from the Westinghouse Post Irradiation Facility (WPIF) to Nuclear Fuel Services for reprocessing. (auth)

**1182** (ORNL-tr-1231) CHINON EDF 3 NUCLEAR POWER PLANT: COLLECTION OF TECHNICAL DATA. Translated for Oak Ridge National Lab., Tenn., from French Report. 135p. Dep. mn. JCL $10.50 fs, $4.25 mf.

A collection of descriptive notes, data cards, diagrams, and other internal working papers is presented on the design, engineering, and operational characteristics of the EDF3 reactor and its auxiliary systems. (H.D.R.)

**1183** (ORNL-tr-1309) NUCLEAR REACTOR INSTALLATION. Simonnot; Rinuy. Translation of French Patent 1,382,728 from Bull. Offic. Propriete Ind., No. 51, 14945(Dec. 18, 1964). 10p. Dep. mn. JCL $1.10 fs, $0.80 mf.

A heat exchanger installation for a nuclear reactor is described in which the gas coolant is at a higher pressure than the working fluid of the heat exchanger. Several heat exchangers are installed in parallel into the coolant circuit and provided with automatic shut-off devices to isolate any individual heat exchanger when a coolant leak into the working fluid is detected. (H.D.R.)

**1184** (ORNL-tr-1350) STUDY OF A REDUCED SCALE MODEL OF A PRESTRESSED CONCRETE VESSEL SUBJECTED TO A LARGE THERMAL GRADIENT. Dubois, F.; Bonvalet, C.; Dawance, G.; Marechal, J.-C. Translated for Oak Ridge National Lab., Tenn., from Ann. Inst. Tech. Batiment Trav. Publics, 18: 1290-1306(Oct. 1965). 35p. Dep. mn. JCL $3.60 fs, $1.25 mf.

A 1/10 scale model of a containment of the EDF-3 type was constructed to study the performance of prestressed concrete containments. Measurements were made of the deformations, cracking, water content, and tendon relaxation during the thermal stress tests. It is concluded that the vessel performs satisfactorily up to 200°C. (D.L.C.)

**1185** (ORNL-tr-1354) PRESTRESSING REINFORCEMENTS OF THE SEEE TYPE WITH A STRENGTH GREATER THAN 100 t. Beghi. Translated for Oak Ridge National Lab., Tenn., from Ann. Inst. Tech. Batiment Trav. Publics, 18: 1353-8(1965). 13p. Dep. mn. JCL $1.60 fs, $0.80 mf.

Prestressing reinforcements using cables and anchors have been developed for the reactor containment vessels for EDF-3 and EDF-4. Descriptions are given of each of the reinforcements and their properties, production problems, and installation. (D.L.C.)

**1186** (ORNL-tr-1374) CALCULATION OF THE THERMAL NEUTRON FLUX AND CURRENTS, ENERGY, AND GAMMA DOSE ON THE AXIS OF A CHANNEL OF A GRAPHITE-$CO_2$ REACTOR: DOMINO 2 PROGRAM FOR THE IBM 7094. Duco, Jacques (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Translated for Oak Ridge National Lab., Tenn., from report CEA-N-591. 64p. Dep. mn. JCL $6.60 fs, $2.12 mf.

The DOMINO 2 program for the evaluation of fluxes and currents from sources on the walls on the axis of cylindrical pipes with varying radius and thickness is described.

The program is used to calculate the fluxes and currents of thermal neutrons and the energy and gamma dose on the axis of an empty channel in the axial upper shield of the EDF2 reactor. (H.D.R.)

**1187** FABRICATION OF STAINLESS STEEL OR ZIRCONIUM ALLOY NUCLEAR TUBES. Delcroix, Jean (CEFILAC, Paris); Jacson, Michel; Gerard, Jacques. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 60, 38-45(July-Aug. 1966). (In French).

The method for processing stainless steel or Zr alloy tubes for use in reactor cores is outlined with emphasis on the particular problem posed in each step involved. Extrusion of the pipes, cold transformation by drawing and rolling, thermal treatment, and surface treatment are described. The controls used to assure a product meeting the rigid specifications for nuclear reactors are outlined. The ultrasonic method used for thickness control and health safety measurements is described in detail. (J.S.R.)

**1188** TWO-DIMENSIONAL MULTIGROUP PROGRAM MCT AND SOME STUDIES ON THE EFFECT OF AXIAL BLANKET IN FAST REACTORS. Reiche, Chr. (Zentralinstitut fuer Kernforschung, Rossendorf, Ger.). Kernenergie, 9: 232-40(July 1966). (In German).

The PDQ code is used with the successive over relaxation method as the inner iteration for MCT and an extrapolation method using Hermitian polynomials as the external iteration. The storage capacity of the computer limits the lattice points to about 800 for four energy groups. Under these conditions, the eigenvalue and blanket size can be calculated with an accuracy of 0.1%. The critical size and the conversion factors were studied as functions of the axial reflector thickness for fast reactors using the program. (J.R.D.)

**1189** USE OF THERMODYNAMICS TO PREDICT REACTIONS ENCOUNTERED IN DEVELOPMENT OF LIQUID-METAL-FUEL NUCLEAR REACTORS. Bidwell, Richard M. (Instituto de Energia Atomica, Sao Paulo, Brazil). Met., ABM (Ass. Brasil. Metais), 21: 71-8(Jan. 1965). (In Portuguese). (IEA-88).

Studies were made of the use of thermodynamics to foresee many reactions of interest for the development of reactors utilizing liquid metal fuel. The explanation for a series of phenomena that occurred during the development of these reactors is simplified through the utilization of thermodynamic data mainly concerning the behavior of impurities which constitute normally interstitial solid solutions with the metals of the jackets which contain the liquid metal fuel. Problems related to the pyrometallurgical reprocessing of the partially utilized fuel and the sacrificial deoxidation technique used to refine the metal were also investigated. The obtained results show good agreement between the theoretical forecast based upon thermodynamic calculations and the experimental results. (auth)

**1190** CALCULATION OF NEUTRON ESCAPE PROBABILITY IN A WATER REACTOR. Huang, Chin-hua. Yuan Tzu Neng, No. 4, 302-13(1965).

The S. G., $B_0 - \Sigma tv$, $P_1$, and $B_1$ methods used in the calculation of the escape probability of fast neutrons in reactors are discussed. A comparison of escape probability obtained by the different methods is tabulated, and a solution to the $P_1$ equation is given. (H.D.R.)

**1191** OPERATION AND PERFORMANCE OF PLANT SYSTEMS DURING LOW POWER TESTING AT PEACH BOTTOM. Kemper, J. S.; Cooney, M. J. (Philadelphia Electric Co., Delta). 29p. (CONF-660606-46). ORAU. Gmelin, AED-CONF-66-203-116.

From American Nuclear Society Meeting, Denver.

The Peach Bottom Reactor, which is owned and operated by the Philadelphia Electric Company and was initiated and supported by fifty-three utility companies of High Temperature Reactor Development Associates, achieved criticality on March 3, 1966. This paper, after a brief description of the plant, discusses the operation and performance of the systems associated with the nuclear steam supply system during the loading and low power program. (auth)

**1192** FUEL CYCLE STUDIES FOR A BERYLLIUM OXIDE MODERATED HIGH TEMPERATURE GAS-COOLED REACTOR. Cairns, R. C.; Baillie, M. G.; Farrell, M. S.; May, J. R. (Australian Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). 40p. (CONF-660524-21). ORAU. Gmelin, AED-CONF-66-104-16.

From 2nd International Thorium Fuel Cycle Symposium, Gatlinburg, Tenn.

The fuel cycle studies undertaken as part of feasibility studies of a BeO-moderated H.T.G.C.R. are described. An outline is given of the developmental work performed in an attempt to devise suitable flowsheets to provide for Th utilization and moderator recycle. Laboratory data for the grind-leach process, which has been selected as the head-end step, are given as well as results obtained using a split-contactor, solvent-extraction flowsheet, which is necessary for actinide recovery and decontamination. Results are given also of laboratory work on the flowsheet selected for Be decontamination. Major flowsheet difficulties in the fuel cycle, and those problems of major consequence requiring experimental and engineering development, are discussed. It is shown that, for recycle to be more economic than open cycle, a reactor installation of greater than 800 MW(e) is required, and that for low fuel cycle costs and Th utilization to be achieved, recycle is essential. It is also shown that major effort and expenditure on the chemical, engineering and design problems outstanding are required before the processes could be established and the predicted costs verified. (auth)

**1193** ENERGY OPTIMAL XENON SHUTDOWN. Lewins, Jeffery; Woodcock, Gordon; Babb, Albert (Univ. of Washington, Seattle). 20p. (CONF-660606-52). ORAU. Gmelin, AED-CONF-66-203-102.

From American Nuclear Society Meeting, Denver.

Pontryagin's optimum theory is applied to the problem of determining a flux shutdown program that limits Xe poisoning in a reactor while using the minimum nuclear energy on flux integral. We determine the complete adjoint solution and synthesize typical optimal trajectories. The analysis is carried through for both the unrestricted problem and the problem where the Xe density is restricted within the control period to some maximum acceptable poisoning. Much of the analysis is similar to the problem where the control time rather than the control energy is to be optimized. Our method of solution is new in utilizing a more straightforward optimum theorem and giving the full solution on the boundary of restriction. It is briefly indicated how the same analysis can be used to give a more rigorous proof of optimality in the time optimal problem. (auth)

**1194** THE ON-LINE DIGITAL COMPUTER FOR THE MARVIKEN NUCLEAR POWER STATION. Tuxen-Meyer, Helge (Aktiebolaget Atomenergi, Stockholm). 10p. (CONF-660533-1). ORAU. Gmelin, AED-CONF-66-123-1.

From International Standards Association, Power Instrumentation Symposium, Detroit.

The Marviken Nuclear Power Station which is now being built in Sweden will include an on-line digital computer as the central feature in the control system. The main functions performed by the computer system will be control of pumps and valves for a proper starting, stopping, and operating sequence; automatic control functions during normal power operation; control of machinery from charging and discharging fuel while the reactor is under load; alarm monitoring; presentation of process variables; and data reduction. (auth)

**1195** THORIUM FUEL CYCLE FOR A BERYLLIUM OXIDE PEBBLE-BED REACTOR. Bicevskis, A.; Hesse, E. W.; Mercer, D. J. (Australian Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). 31p. (CONF-660524-20). ORAU. Gmelin, AED-CONF-66-104-15.

From 2nd International Thorium Fuel Cycle Symposium, Gatlinburg, Tenn.

Details are given of an investigation of the nuclear and some cost aspects of the Pu-Th-BeO pebble bed reactor

(PBR) study. The all ceramic core coupled with neutron enhancement in BeO provides an excellent neutron economy which is conducive to efficient utilization of Th. Burnup studies for the once-through system were carried out to select the fuel composition on economic grounds satisfying the constraints of reactivity lifetime, power density limits, etc. A zero-dimensional model was developed based on the equilibrium spectrum which is ideally suited to the recirculated fuel in a PBR. Fuel recycling was considered with Pu as the make-up fuel in addition to reprocessed U-233. The PBR concept permits great flexibility in fuel management and some preliminary investigations based on perturbation theory indicate promising schemes worthy of further study. A space dependent fuel management–burnup code accounts for local spectrum and temperature effects. Some management schemes which are feasible with the proposed core layout were investigated. The economic investigations indicate that for the closed cycle there is very little change in fuel cycle costs for moderator to fissile atom ratios of 1000 to 2500. The present cost of BeO is high and plant optimization studies lead to relatively low moderator ratios and an epithermal neutron spectrum. Only $^{233}U$ retains a reasonable $\eta$-value in such systems and therefore Th–U-233 cycles have the best neutron economy. Th can also be used to advantage to improve power density distribution and thus reduce capital costs. (auth)

## Marine and Portable Power Reactors

**1196** (NUS-220) THE FIRST CORE REPLACEMENT [AT] PM-3A NUCLEAR POWER PLANT, McMURDO STATION, ANTARCTICA. (Nuclear Utility Services, Inc., Washington, D. C.). Mar. 17, 1965. Contract DA-44-009-AMC-547(X). 154p.

The replacement of the first core at the PM-3A Nuclear Power Plant is reviewed with the objective of delineating the lessons learned and recommending actions which should be taken so that future refuelings can be performed more expeditiously. Significant steps taken in preparation for the fueling operation, removal of the spent core, and installation of the replacement core are discussed, and specific problems encountered in the fueling operation together with recommendations for future refuelings are presented. (H.D.R.)

## Rocket and Space Reactors

*Refer also to abstracts 604, 1197, and 1199.*

**1197** (NAA-SR-11906) SNAPTRAN 10A/2 KINETICS TESTING AND DESTRUCT REACTOR EXPERIMENTS. Johnson, R. P. (Atomics International, Canoga Park, Calif.). July 15, 1966. Contract AT(11-1)-Gen-8. 113p. Dep. mn. CFSTI $4.00 cy, $0.75 mn.

In a series of nondestructive tests and a destructive test conducted for the Aerospace Nuclear Safety Program, the nuclear safety of a SNAP-10A/2 type reactor was investigated. These tests were performed using the SNAPTRAN-1 and -2 reactors. The transient tests performed on the SNAPTRAN-1 reactor provided information which led to a better understanding of the inherent reactivity feedback characteristics of this and similar reactors. Step and impulse insertions introduced nondestructive reactivities up to $4.15 during the transient series. A destruct test, designated as the SNAPTRAN-2, was conducted to measure the reactivity feedback effects, including those of rapid mechanical expansion. The reactivity input during the destruct test was $5.06. The radiological effects during and after the excursion were determined. (auth)

**1198** (NAA-SR-Memo-10446) SNAP-10A FSM-4 PERFORMANCE ANALYSIS: NaK LOADING AND THERMAL REFERENCE TEST. Berg, G. E. (Atomics International, Canoga Park, Calif.). Sept. 15, 1964. Contract AT(11-1)-Gen-3. 28p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Data taken during NaK loading and thermal reference testing of the SNAP-10A FSM-4 non-nuclear ground test system are presented and analyzed. For purposes of analysis the performance was divided into five categories: system temperatures, system heat losses, converter electrical performance, pump performance, and flight instrumentation performance. In each category emphasis was placed on comparison of measured data to predicted performance and thermal reference performance of the 10FSM-1 and 10FS-1 systems. In almost every case both FSM-4 performance and agreement with predicted values were excellent. An average of 509 watts was produced at a core outlet temperature of 1011°F. The only important problem was a low converter to ground resistance which would have caused a very small decrease in power output if the system had been grounded. (auth)

**1199** (NAA-SR-Memo-11845) GAS-SURFACE INTERACTIONS FOR SNAP FUEL PARTICLE REENTRY. Thermo-Physics Technical Note No. 59. Johnson, H. E. (Atomics International, Canoga Park, Calif.). Mar. 21, 1966. Contract AT(11-1)-Gen-8. 43p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

A survey of various physical and chemical interaction processes of SNAP fuel particles re-entering the atmosphere has been made. The particles are expected to re-enter the atmosphere primarily in the transition flow regime with initial breakup due to air pressure forces overcoming surface tension forces as defined by the Weber criteria. Vapor pressure equations for SNAP fuel components with the Langmuir equation to calculate evaporation rates are given. Evaporation will then further reduce particle sizes from the primary ablation product sizes estimated by the Weber method. Chemical as well as physical interaction processes are considered with low temperature oxidation processes making a transition to high temperature processes. Zr and Zr alloys oxidize by cubic, parabolic, and linear rate laws. Metals apparently ignite at or before the transition from parabolic to linear kinetics. Dissolved fission products or atmospheric gases may cause explosions at various possible times during the particle temperature cycle. Recommendations are made in regard to improvements in the dual analytical-experimental program with three types of experimental programs: (1) simulation type experiments, (2) high temperature physical and chemical parameter determinations, and (3) fission product release studies. (auth)

**1200** (NAA-SR-Memo-11847) THERMAL ANALYSIS OF SNAP-10A REACTOR CORE DURING ATMOSPHERIC REENTRY AND RESULTING CORE DISINTEGRATION AND FUEL ELEMENT SEPARATION. Thermo-Physics Technical Note No. 60. Mouradian, E. M. (Atomics International, Canoga Park, Calif.). Feb. 16, 1966. Contract AT(11-1)-Gen-8. 154p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

A thermal analysis is carried out to determine the temperature distribution throughout a SNAP 10A reactor core, particularly in the vicinity of the grid plates, during atmospheric reentry. The transient temperature distribution of the grid plate indicates when sufficient melting occurs so that fuel elements are free to be released and continue their descent individually. The flight trajectories and heating functions are discussed. Among the topics considered are the aerodynamic drag coefficients for different flight orientations, aerodynamic heating functions, and reentry flight trajectory parameters. The local effect of the fuel element pins on the temperature distribution in the grid plate is discussed. The temperature distributions in the reactor core grid plates during reentry are given. The applicability of the results to different flight trajectories is also considered. The thermal models developed to investigate the above problems are used with the TAP-3 (Thermal Analyzer Program) computer code. Flight trajectory calculations are carried out by means of the RESTORE (Reentering SNAP Trajectory on an Oblate Rotating Earth) computer code. (auth)

**1201** (NASA-TM-X-1292) ANALYSIS OF CONDENSING PRESSURE CONTROL FOR SNAP-8 SYSTEM.

Packe, Donald R.; Schoenberg, Andrew A.; Jefferies, Kent S.; Tew, Roy C. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Oct. 1966. 26p. CFSTI $1.00 cy, $0.50 mn.

The expected variations of condensing pressure and methods for controlling these variations in the SNAP-8 Rankine space power system were investigated. The effects of environmental disturbances and component degradation on the system operation were studied by means of a steady-state digital computer simulation of the heat-rejection loop and condenser. This study indicated that condensing pressure control may be required to prevent the pressure from exceeding the maximum permitted turbine back pressure required to achieve rated power output or from going below the value necessary to prevent cavitation of the power loop pump. Several methods of controlling condensing pressure were investigated also by steady-state simulation on the digital computer. The most promising forms of control were found to be condenser coolant bypass flow control and condensate inventory control by an accumulator. The dynamic characteristics of these two forms were studied in detail, both by computer simulation and transfer function analysis techniques. These studies led to the conclusion that for the expected space environment and for present system compatibility including ground testing, the condenser coolant bypass flow control is the best form of pressure control. This method of control is flexible in that its development may parallel system development on a noninterference basis and at a later date may be severed from the program if tests indicate that it is not needed. This feedback control system is expected to be stable, to operate effectively under acceleration conditions, and to maintain condensing pressure well within specified limits under all expected disturbances within the anticipated system flight envelope. (auth)

**1202** (NP-16337) THEORETICAL INVESTIGATION OF RADIANT HEAT TRANSFER IN THE FUEL REGION OF A GASEOUS NUCLEAR ROCKET ENGINE. Report E-910092-9. Kesten, Arthur S.; Krascella, N. L. (United Aircraft Corp., East Hartford, Conn. Research Labs.). Sept. 1966. Contract NASw-847. 28p.

A series of calculations were made to determine temperature distributions in the fuel-containment region of gaseous nuclear rocket engines which are based on the transfer of energy by thermal radiation from the fuel to the propellant. Temperature distributions were determined for two sets of fuel opacities; the opacities in each of these sets were calculated from an analytical heavy-atom model using two recent theoretical estimates of fuel ionization potentials. The temperatures near the centerline of the fuel-containment region were found to be high and relatively insensitive to changes in fuel opacity. (auth)

**1203** (WCAP-2993) FEASIBILITY OF A CHEMICAL POISON LOOP SYSTEM. Final Report. Eanes, W. F.; Fultonberg, D. N.; Rosal, E. R.; Fletcher, W. D.; Loving, J. J. (Westinghouse Electric Corp., Pittsburgh, Pa. Atomic Power Div.). Sept. 1966. Contract NAS3-5215. 75p. (NASA-CR-72105).

The final experiments performed with the Laboratory Version of the Chemical Poison Loop System (CPLS) are described and the results are analyzed. An overall discussion of the feasibility of using a CPLS to control the reactivity of a rocket reactor is contained, wherein it is concluded that the system should be hydraulically and thermally feasible. However, certain chemical instability problems which were not resolved in the work performed make overall feasibility marginal. (auth)

## Process Heat and Desalination Reactors

**1204** (ORNL-TM-1561) SURVEY OF PROCESS APPLICATIONS IN A DESALINATION COMPLEX. Holmes, J. M.; Ullmann, J. W. (Oak Ridge National Lab., Tenn.). Oct. 1966. Contract W-7405-eng-26. 68p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

A survey of the chemical and metallurgical industries was made to ascertain which processes should be given priority for further detailed study as possible components of a nuclear industrial-desalination complex. Factors studied included market potential, demand for large quantities of power or steam, shipping costs, production costs, and economics expressed as turnover ratios. (auth)

## Research and Test Reactors and Critical Assemblies

**1205** (BMI-X-10170) SUMMARY REPORT ON DEVELOPMENT OF A FUEL SYSTEM FOR A FAST-FLUX PULSE REACTOR. Farkas, Martin S.; Redmond, Robert F.; Keller, Donald L. (Battelle Memorial Inst., Columbus, Ohio). June 29, 1966. Contract W-7405-eng-92. 41p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

Potential fuel materials were identified for a pulse reactor which will provide a fast flux of $10^{16}$ nvt in a few milliseconds. Available data regarding the physical, thermal, and chemical properties, and compatibility behavior of fuel and cladding materials which conceivably might be suitable for pulse reactors were compiled. Chief emphasis was put on thermal properties and also on potential compatibility problems when claddings were indicated. The work was carried out in close coordination with reactor physics studies. Data for materials potentially applicable to the five pulse-reactor fuel-system concepts jointly evolved were collected and analyzed. The five reactor fuel-system concepts considered in the analyses were alloy, dispersion, ceramic, graphite, and molten salt. Potential reactor physics feasibility for all five systems was demonstrated in preliminary calculations. Nb-base-U alloys were selected as the fuel for the alloy concept, while $UF_4$-73 m/o LiF appears to be the only candidate for the molten-salt concept. It was concluded that the available information could not support selection of single fuel systems for the dispersion, ceramic, and graphite concepts. The primary candidates for these systems are, respectively, Nb-$UO_2$ and W-$UO_2$ dispersions, $UO_2$ and $UO_2$-BeO, and coated $UO_2$ particles in graphite and $UC_2$ particles in graphite. (D.L.C.)

**1206** (IDO-17206) SPERT PROJECT. Quarterly Technical Report, January-March 1966. Potenza, R. M. (ed.) (Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div.). Sept. 1966. Contract AT(10-1)-205. 72p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Loading of a slightly enriched oxide core, the E-core, in the Spert III facility was completed. Measurements were made on the E-core control rod and transient rod reactivity worths and the reactivity worth of fuel assemblies in several core positions. The E-core temperature and pressure coefficients of reactivity were independently measured as functions of system temperature. Short-period power transient tests were performed with encapsulated test fuels positioned in the Capsule Driver Core (CDC) test space. Two fuel types were irradiated: lead rods that are normal 3%-enriched CDC fuel rods, and 4%-enriched Spert I oxide core fuel rods containing purposely induced cladding defects and known amounts of water. Fuel rod failures occurred during each of the tests. The reduced prompt neutron generation time was determined using the CDC transient test. Out-of-pile experiments were conducted with scaled mockups of the Power Burst Facility (PBF) in-pile-tube (IPT) and acoustic filter system. Different types of chemical explosives were detonated within the IPT and associated acoustic filter to generate a wide range of pressure pulse magnitudes and durations. Pressure and strain measurements were used to determine the system attenuation capabilities and preferred acoustic filter design. (H.D.R.)

**1207** (IS-1425) IN-PLACE TESTING OF CHARCOAL FILTER BANKS AT AMES LABORATORY RESEARCH REACTOR (ALRR). Gukeisen, C. A.; Malaby,

K. L. (Ames Lab., Iowa State Univ. of Science and Tech.). Sept. 1966. Contract W-7405-eng-82. 13p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The air exhaust system at the ALRR is described. An experimental program was conducted to develop an appropriate in-place iodine test for the charcoal filter banks. Three techniques were tested: spectrophotometric analysis, neutron activation, and $^{131}I$ tracer. Comparisons of the testing results and experience are enumerated with comments and recommendations. The neutron activation and the $^{131}I$ tracer techniques proved to be the most appropriate methods for in-place testing of the ALRR charcoal filter banks. (auth)

**1208** (LA-DC-7962) COMPARISON OF MULTIGROUP CROSS SECTION SETS USED IN REACTOR CALCULATIONS. Battat, M. E.; LaBauve, R. J. (Los Alamos Scientific Lab., Univ. of California, N. Mex.). [1965]. Contract W-7405-eng-36. 12p. (CONF-661019-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From International Conference on Fast Critical Experiments and Their Analysis, Argonne, Ill.

In order to provide a common basis for comparing various neutron multigroup cross-section sets, calculational models of two well defined critical experiments were specified. The critical assemblies chosen for this study were the Jezebel (Pu) assembly and the 610-liter ZPR VI (Assembly No. 2) UC core. The Hansen-Roach 16-group and Russian 26-group cross-section sets were used for the initial comparisons. Calculations were made to determine the critical core volumes and central reactivity worths using the DTF-IV transport code in the $S_8$ approximation and assuming spherical geometry. In addition, two types of perturbation theory calculations were made to arrive at central reactivity worths for small samples. The first of these is used to compute worths in terms of simple atomic perturbation cross sections. The second is based on transport perturbation theory, using real and adjoint currents and fluxes, with results expressed in terms of $\Delta k/g$-atom. Wherever available, experimental data are presented for comparison with calculations. Central reactivity worths have been calculated for the following materials: $^{239}Pu$, $^{240}Pu$, $^{238}U$, $^{235}U$, depleted U, Fe, Ni, Cr, Na, Ta, Al, Mo, and B. In the case of ZPR VI, the reactivity effect of voiding the core Na was also calculated. (auth)

**1209** (NAA-SR-11359) TR-SRE FAST-FLUX IRRADIATION FACILITY. Utilization Program. (Atomics International, Canoga Park, Calif.). June 3, 1965. Contract AT(11-1)-Gen-8. 71p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The supporting role and utilization of the TR-SRE, a proposed modification of the existing Sodium Reactor Experiment Facility, in the Fast Breeder Reactor Irradiation Program are described. The installed Fast Flux Region will be used for fuel and cladding tests at neutron flux, temperature, and fuel exposure rates typical of projected fast reactor designs. (H.D.R.)

**1210** (NAA-SR-Memo-8364) PRELIMINARY RADIOLOGICAL HAZARD ANALYSIS FOR THE FARET REACTOR. Simon, N. K. (Atomics International, Canoga Park, Calif.). Apr. 2, 1963. Contract AT(11-1)-Gen-8. 36p. Dep. mn. CFSTI $2.00 cy, $0.50 mn.

The radiological hazard to the environment is analyzed with respect to the radioisotope release from two reactor accidents: the core melts down and forms a supercritical mass which releases an energy equivalent to the detonation of 300 lbs TNT and a fuel element falls out of the fuel handling machine onto the reactor cell floor and burns. A computer code was used to compute the radioisotope release and subsequent dose to the environment from these accidents. The exclusion radius for the FARET reactor was determined to be 0.06 miles (330 ft). The low population zone radius was determined to be 1.6 miles for design conditions under which the largest radioactive release occurred in the cases studied. (auth)

**1211** (ORNL-TM-1532(Rev.)) OPERATING SAFETY LIMITS FOR THE HIGH FLUX ISOTOPE REACTOR (HFIR) (100 Mw MAXIMUM POWER). (Oak Ridge National Lab., Tenn.). Sept. 16, 1966. Contract W-7405-eng-26. 11p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Limits for operating variables which have a direct reactor safety significance are established. Each limit designates a realistic boundary to the operating range of the variable. (H.D.R.)

**1212** (ORNL-TM-1667) OPERATING SAFETY LIMITS FOR THE OAK RIDGE NATIONAL LABORATORY BULK SHIELDING REACTOR (BSR). Stanford, L. E.; Webster, C. C. (Oak Ridge National Lab., Tenn.). Oct. 19, 1966. Contract W-7405-eng-26. 10p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

The operating safety limits specified were determined by design or experience, and are listed according to the functional components. One section indicates what limitations are placed on experiments, and another section specifies the limitations placed on administration of the operation. (auth)

**1213** (UCRL-Trans-10057) REGULATION OF THE NEUTRON FLUX BY THE $^{16}N$ ACTIVITY OF THE COOLANT IN THE MUNICH RESEARCH REACTOR. Sommer, W. Translated for Univ. of California Lawrence Radiation Lab., Livermore, from Regelungstech., 13: 443-8(1965). 25p. Dep. mn. JCL $2.60 fs, $0.95 mn.

An automatic reactor control system is described which yields a constant average neutron flux in the core by measuring the $^{16}N$ activity of the coolant. A core arrangement is discussed in which the distribution of the core flux is nearly independent of the varying control rod positions. Neutron flux measurements at different poisoning states confirm the reduced variations of local fluxes as a consequence of the improved control system. (auth)

**1214** ESTIMATION OF DILUTION RATES FOR CONTINUOUS RELEASES USING TRITIUM. Soman, S. D.; Abraham, P. (Atomic Energy Establishment, Trombay, India). 14p. (CONF-660621-17). ORAU. Gmelin, AED-CONF-66-193-7.

From Health Physics Society, 11th Annual Meeting, Houston, Tex.

Cold finger samples from the exhaust system of the CIRUS reactor at Trombay were analyzed for tritium content to estimate the rate of release of tritium. The methods adopted for the estimation of tritium and the results obtained are presented. The variation in the release rate with the build-up of tritium activity in the heavy water for different values of heavy water content in the exhaust air is presented graphically. A portable sampler developed at Trombay was used for the collection of moisture samples from different locations. The dilution rates available at the site during different seasons of the year are obtained. (auth)

## Production Reactors

*Refer also to abstract 1215.*

**1215** (DPSPU-66-30-5) ON-LINE COMPUTERS FOR LARGE NUCLEAR REACTORS. Ryder, F. D. (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Plant). Apr. 1966. Contract AT(07-2)-1. 14p. (CONF-660434-1). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From 8th Symposium on Process Automation, Newport Beach, Calif.

An on-line computer is being used to improve the operating safety and efficiency of a production reactor at the Savannah River Plant. The computer is programmed to monitor the analog signals from approximately 3300 process sensors. It provides guidance for operating personnel in controlling the reactor and initiates corrective action automatically if some selected operating limits are exceeded. The programs have been designed to accommodate the various types of U fuel assemblies used in the reactor and to operate unattended over a wide variety of reactor operating conditions. (auth)

**1216** (DUN-SA-14) RADIOLOGICAL ASPECTS OF THE DEACTIVATION OF HANFORD PRODUCTION REACTORS. Wallis, Lynn R.; Corbit, Carl D. (Douglas United Nuclear, Inc., Richland, Wash.). Aug. 9, 1966. Contract AT(45-1)-1857. 40p. (CONF-660920-8). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From 1st International Congress of the International Radiation Protection Assn., Rome, Italy.

The deactivation procedures and monitoring and control programs are reviewed for the deactivation of three Hanford reactors. Experience gained over a one year period indicates the radiological criteria adhered to during the deactivation were sufficiently restrictive and the periodic radiation and contamination surveillance program for the reactors is adequate. (H.D.R.)

**1217** (DUN-SA-15) CONFINEMENT SYSTEMS TESTS PERFORMED DURING DEACTIVATION OF THE 100-F REACTOR. Smith, M. L. (Douglas United Nuclear, Inc., Richland, Wash.). July 21, 1966. Contract AT(45-1)-1857. 30p. (CONF-660904-12). Dep. mn. CFSTI $2.00 cy, $0.50 mn.

From 9th Air Cleaning Conference, Boston, Mass.

Permanent shutdown of 100-F Pu production reactor at Hanford made the system for confining the particulate and halogen, in the exhaust air, available for testing. Results are shown for tests on $I_2$ deposition from the airstream, $I_2$ removed from airstream by fog spray, encapsulation of the reactor exhaust air in foam, effectiveness of fog spray for removing noble gases from the air, and effectiveness of the filter system for removing $I_2$ from the exhaust air. (auth)

## Reactor Components, Fuels and Accessories

*Refer also to abstracts 98, 342, 447, 472, 515, and 518.*

**1218** (CONF-660606-38) A SEMI-THEORETICAL EQUATION FOR PREDICTING BURNOUT FOR SINGLE-ROD AND MULTI-ROD EXPERIMENTS. Nichols, Charles R. (Hydrospace Research Corp., Rockville, Md.). [1966]. Contract AT(30-1)-2404. 13p. Dep. mn. CFSTI $1.00 cy, $0.50 mn.

From American Nuclear Society Meeting, Denver.

A semi-theoretical equation is developed for relating the burnout heat flux for forced convection heat transfer experiments with uniform heat generation to the test geometry, the coolant mass velocity, and the fluid properties. The burnout heat fluxes predicted by this equation agree with results of single-rod and multi-rod heater experiments. (H.D.R.)

**1219** (EURAEC-1682) THE STEADY STATE AND DYNAMIC BEHAVIOR OF A BOILING WATER REACTOR. Quarterly Progress Report No. 21, January 1–April 1, 1966. (Technische Hogeschool, Eindhoven (Netherlands)). Contract 030-64-1 Teen. 21p. (WW-016-R-108; EUR-2869). Dep. mn. CFSTI $1.00 cy, $0.50 mn.

Work Performed under United States–Euratom Joint Research and Development Program.

Measurements are reported which have been carried out to check the influence of a changing waterlevel on the steady as well as the non-steady state characteristics of the hydraulic system. The effect appears to be negligible provided that the level is above the edge of the shroud. The results of the 50 mm and the 60 mm shroud measurements have been further analyzed. Void fraction data have been plotted as a function of the Martinelli-Nelson parameter. The figures indicate that the parameter $X_{tt}$ might be a suitable parameter for correlation. Burnout data obtained from the measurements on the 50 mm and 60 mm shrouds are given as a function of saturation temperature and subcooling. (auth)

**1220** (GEMP-432) SAHARA STATUS REPORT: A MODIFIED ORNL REACTOR BURNUP CODE. Prickett, W. Z. (General Electric Co., Cincinnati, Ohio. Nuclear Materials and Propulsion Operation). Aug. 1, 1966. Contract AT(40-1)-2847. 129p. Dep. mn. CFSTI $4.00 cy, $1.00 mn.

The current status of the SAHARA burnup code for the GE-625 computer is summarized. This code is based on the ORNL-LTM code. Recommendations are indicated for further improvement in the code. User instructions and sample problems are provided. Complete listings are included. (auth)

**1221** (JUL-378-RG) VERFAHREN ZUM AUTOMATISCHEN AUSTAUSCH VON SCHALENTEILCHEN BEI KUGELFOERMIGEN BRENNELEMENTEN. (Method for the Automatic Exchange of Scale Particles on Spherical Fuel Elements). Baurmann, K. W.; Hammelmann, K. H.; Tschakert, W. (Kernforschungsanlage, Juelich (West Germany). Institut fuer Reaktorentwicklung). Apr. 1966. 26p. Dep. mn.

In the use of spherical fuel elements for a reactor, the scale particles present in the fuel element in loose fill can be separated from the sphere after reactor shutdown. The sealed hole for the introduction and removal of scale particles can be mechanically fixed so that after boring open, the particles will flow out of the fuel element. Then the element can be filled with new particles. Three versions of an apparatus for particle exchange were developed. The advantage of one device is that the total surface can be scanned without clamping the sphere. A combination of scanner and borer permits several work operational processes in the same apparatus. Individual components are still in the experimental stage. An automatic control for the device was developed. A mechanical sealing technique of the fuel element is still to be developed for completion of the device. (tr-auth)

**1222** (ORNL-TM-1588) STUDY OF FISSION PRODUCTS RELEASED FROM TRACE-IRRADIATED $UO_2$ INTO STEAM–AIR ATMOSPHERES (NUCLEAR SAFETY PILOT PLANT RUNS 8 AND 9). Parsly, L. F.; Row, T. H. (Oak Ridge National Lab., Tenn.). May 20, 1966. Contract W-7405-eng-26. 94p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

Two experiments are reported in which fission products from trace level irradiated, stainless clad, normal $UO_2$ fuel pins are released into a 1350 $ft^3$ model containment vessel by melting the pins in a steam atmosphere with a plasma torch. The data obtained include distribution of fission products in the system after melting, material balances, condensate accumulation rate, rate of accumulation of fission products in condensate, concentration of fission products in the containment vessel atmosphere vs time, and deposition on a variety of surfaces. (auth)

**1223** (SAN-1013(Vol.2)) TRANSIENT BOILING PHENOMENA. VOLUME II. EXPERIMENTAL RESULTS. Final Report. Schrock, V. E.; Johnson, H. A.; Gopalakrishnan, A.; Lavezzo, K. E.; Cho, S. M. (California Univ., Berkeley. Coll. of Engineering). May 1966. Contract AT(11-1)-34. 130p. Dep. mn. CFSTI $4.00 cy, $1.00 mn.

Exponential transient data collected on transient pool boiling and transient boiling in channel tests are summarized. The four basic test parameters investigated were pressure, subcooling, exponential period, and velocity. (H.D.R.)

**1224** (STI-PUB-115) NUCLEAR ELECTRONICS. Proceedings Series. Proceedings of a Conference held in Bombay, 22–26 November 1965. (International Atomic Energy Agency, Vienna (Austria)). June 1966. 664p. (CONF-651105). IAEA: $13.50; S 283.50; £4.1.0; F Fr 54,–; DM 47,25.

The use of nuclear electronics in reactor control and safety is examined. Presented are 48 papers on power and neutron flux measurements, reactor control, safety devices, and data processing to ensure optimum operation. (H.D.R.)

**1225** (TID-6506(Pt.1)(4th Ed.)) SUMMARIES OF FUELS AND MATERIALS DEVELOPMENT PROGRAMS. Rice, William L. R. (ed.) (Division of Reactor Development and Technology (AEC), Washington, D. C.). Mar. 1966. 213p. Dep. mn. CFSTI $6.00 cy, $1.25 mn.

Descriptions are given of the research and development programs directed by the Fuels and Materials Branch of the Division of Reactor Development and Technology. The contractors are listed alphabetically, and a subject index is included. (D.L.C.)

**1226** (ORNL-tr-1310) IMPROVEMENTS MADE IN ESPECIALLY SPHERICAL VESSELS OF LARGE SIZE. Plasseraud, Devant; Gutmann, Jacquelin. Translation of French Patent 1,345,154 from Bull. Offic. Propriete Ind., No. 49, 13432(Dec. 6, 1963). 9p. Dep. mn. JCL $1.10 fs, $0.80 mf.

A device is designed for absorbing the secondary stresses that result from the thermal expansion of a pressure vessel having an interlock. The device comprises an elastic means (springs of rubber or elastomer disks) which support the interlock. The platform inside the interlock is made stationary by rods in the springs which connect the platform with its foundation. (D.L.C.)

**1227** THE INDUSTRIAL FABRICATION OF NUCLEAR FUEL ELEMENTS IN FRANCE. Jeanpierre, G.; Nifenecker, P. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 60, 16-20(July-Aug. 1966). (In French).

The principal characteristics of fuel elements for graphite-gas and heavy water-gas reactors are described. The policy of the CEA is for private industry to be responsible for fabricating reactor fuel elements. The three phases in the transfer to private industry of the responsibility for fuel element fabrication are outlined. (J.S.R.)

**1228** AN APPARATUS TO MEASURE THE THERMAL DIFFUSIVITY OF IRRADIATED FUEL SPECIMENS AT TEMPERATURES UP TO 1200 DEG C BY THE FLASH METHOD. Shaw, D.; Goldsmith, L. A. (United Kingdom Atomic Energy Authority, Sellafield, Eng.). J. Sci. Instrum., 43: 594-6(Aug. 1966).

An apparatus to measure the thermal diffusivities of samples of irradiated nuclear fuels at temperatures up to 1200°C is described. A disk-shaped specimen is heated to the desired test temperature in a vacuum furnace. A heat pulse from a ruby laser is absorbed on one face of the specimen and the temperature rise at the rear face is followed by means of the thermal radiation emitted from it. A cone of this radiation is collected by a concave mirror, transmitted through an optical system and focused on to a Pbs detector. The output from this is amplified and fed to an ultra-violet, high-speed recorder. (auth)

**1229** INVESTIGATION OF THERMAL BOWING OF FUEL ELEMENTS. Safronov, E. Ya.; Briskman, B. A.; Bondarev, V. D.; Shishov, V. S. At. Energ. (USSR), 21: 22-6(July 1966). (In Russian).

The temperature drop on the walls of fuel elements of the adaptor type was calculated for conditions of radial neutron flux gradients. The thermal bowing of the walls was measured in the operating range of temperature drop. (tr-auth)

**1230** SEALING SYSTEM FOR THE HANDLING HOOD OF A NUCLEAR REACTOR. Chemin, Paul; Lephilibert, Jean (to Commissariat a l'Energie Atomique). Canadian Patent 733,190. Apr. 26, 1966. Priority date Oct. 25, 1961, France.

The shielded flask mounted on a trolley can be joined to any fuel channel by means of an eccentric top plate. A stationary ring is joined to a sealing ring with compression springs so that fluid tight joint is obtained to maintain coolant flow during fuel changing. An extensible cylindrically shaped bellows assists in maintaining the seal. (F.S.A.)

**1231** NUCLEAR REACTOR CONTROL ROD PRESSURE-ACTUATED DRIVING MECHANISM. Tollet, Louis H. J.; Maldague, Pierre E. J. M. (to Societe Anglo-Belge Vulcain Societe Anonyme). Canadian Patent 733,607. May 3, 1966. Priority date Mar. 9, 1961, Belgium.

Neutron absorbing rods are moved hydraulically into and out of the reactor core by taking advantage of the normal reactor pressure and imposing a slightly lower pressure from the outside. In the event of low pressure within the reactor because of incorrect operation a trip is effected immediately by the steady outside pressure. The mechanics of the device are somewhat intricate and certain variations in the procedure are described. (F.S.A.)

**1232** METHOD AND APPARATUS FOR MANUFACTURING BALL-SHAPED PARTICLES. Bildstein, Hubert (to Osterreichische Studiengesellschaft fuer Atomenergie GmbH). Canadian Patent 727,738. Feb. 8, 1966. Priority date Oct. 9, 1961, Austria.

Granules from 40 to 260 $\mu$ composed of the oxides or carbides of Mo, W, U, Th, Ti, Zr, Hf, Ta, and Bo for use in nuclear reactors are made by this process. Using an inert atmosphere in a steel container, the powered material is subjected to a high frequency arc between three graphite electrodes which provides a temperature above the melting point. Ball-shaped particles fall to the bottom of the cone where the temperature is below their melting point and they are removed as solids. (F.S.A.)

# GENERAL

**1233** (ORNL–3991) LIKELIHOOD RATIO TEST CRITERION FOR SMALL SAMPLES FROM MULTINOMIAL DISTRIBUTIONS. Preliminary Report. Uppuluri, V. R. Rao; Bowman, Kimiko O. (Oak Ridge National Lab., Tenn.). Sept. 1966. Contract W-7405-eng-26. 52p. Dep. mn. CFSTI $3.00 cy, $0.50 mn.

The small sample properties of the likelihood ratio test statistic ($-2 \log \Lambda$) are studied in detail in the case of the trinomial distributions $(\frac{1}{3} + \frac{1}{3} + \frac{1}{3})^n$ and $(0.3 + 0.5 + 0.2)^n$. These distributions often appear in the literature in connection with Pearson's $\chi^2$ statistic for n equal to 10 and n equal to 20. A critical review of these papers is given. In order to study the rapidity of convergence of the distribution of the discrete random variable $-2 \log \Lambda$ to the theoretical $\chi^2$ distribution with two degrees of freedom, areas to the right of fixed points 9.210, 7.378, 5.991, 4.605, 2.408, 1.386, 0.713, and 0.211, and the critical values with given tail areas 0.01, 0.025, 0.05, 0.10(0.20) 0.90 are computed for several values of n. To indicate the rapidity of convergence of the sizes of these two test criteria, the 95% acceptance regions are graphically displayed in the case of these two trinomials over a few sample sizes. Another comparison is made in terms of the frequency with which the partitions give rise to the numerical values of the two statistics which will lie between preassigned numbers, and the frequency of partitions, with which the cumulative probability distributions of these two statistics, lies between preassigned numbers. For a given sample size this set of tables indicates the closeness of the distributions of these two statistics to the limiting $\chi^2$ distribution with two degrees of freedom. (auth)

**1234** (SC-DR-65-511) THE TTA GENERALIZED RIGID BODY TRAJECTORY PROGRAM FOR DIGITAL COMPUTER. Allensworth, J. A. F. (Sandia Corp., Albuquerque, N. Mex.). Aug. 1966. Contract AT(29-1)-789. 151p. Dep. mn. CFSTI $5.00 cy, $1.00 mn.

Much valuable information concerning the movement of bodies in space can be obtained by the computation of theoretical trajectories. The TTA program was designed, not only to meet the developing requirements for trajectories, but to reproduce data from the actual range environment and to place the program into the hands of the user. TTA permits requesting the trajectory by means of a flexible language which is similar to English. The language and data structure of TTA permits adaptation to a large number of objectives. (auth)

**1235** (UCRL–50105) TWO-DIMENSIONAL STATISTICAL HYDRODYNAMICS. Neuman, M. (California Univ., Livermore. Lawrence Radiation Lab.). July 1966. Contract W-7405-eng-48. 85p. Dep. mn. CFSTI $3.00 cy, $0.75 mn.

The question of expanding a finite box to an infinite plane is discussed in detail; real and complex infinite dimensional phase spaces are introduced and also some related notions pertaining to holomorphic and antiholomorphic properties of functions on such spaces. The countable infinity of first integrals in the limit of vanishing viscosity is considered. The motion in phase space, both globally and locally, is described. Following other discussions, a marginal distribution for the vorticity in a single mode is derived: the analog of the Maxwell-Boltzmann distribution. (M.O.W.)

**1236** (AEC-tr–4919) NUKLEONIKA. Translation of Nukleonika, 8: 1-856(1963). 801p. Dep. mn. CFSTI $11.00 cy, $3.25 mn.